AMERICAN ENGINEER AND RAILROAD JOURNAL.

Formerly the RAILROAD AND ENGINEERING JOURNAL.

(ESTABLISHED IN 1832.)

THE OLDEST RAILROAD PAPER IN THE WORLD.

The American Railroad Journal, founded in 1832, was consolidated with Van Nostrand's Engineering Magazine, 1867, forming the Railroad and Engineering Journal, the name of which was changed to the American Engineer and Railroad Journal, January, 1893.

PUBLISHED MONTHLY AT NO. 47 CEDAR STREET, NEW YORK.

M. N. FORNEY, . . . Editor and Proprietor.
FRANK J. FRENCH, . . . Business Manager.

Entered at the Post Office at New York City as Second-Class Mail Matter.

SUBSCRIPTION RATES.

Subscription, per annum, Postage prepaid.....$3 00
Subscription, per annum, Foreign Countries..... 3 50
Single Copies..... 25

Remittances should be made by Express Money-Order, Draft, P. O. Money-Order or Registered Letter.

NEW YORK, JANUARY, 1894.

EDITORIAL NOTES.

THE electric headlight for locomotives seems to possess advantages above that of merely giving the engineer a longer range of sight, in that the bright beam of light is plainly visible to those far in advance of the engine. It thus serves as a warning of its approach and may serve to avert collisions, unless trainmen become careless and, expecting it, delay sending back a flagman because the electric headlight was not seen.

THERE has been considerable criticism in marine circles, since the loss of the *Victoria*, on the practice of using longitudinal bulkheads. The objection is based on the ground that, in case of injury to the plating, a side compartment may fill and careen the vessel until her stability is lost and an overturn be the result, whereas with transverse bulkheads only, the vessel would merely settle by the head or stern. In our own construction, as exemplified by the *New York*, longitudinal bulkheads are used only along the machinery space.

IT must be exceedingly gratifying to those who have been actively engaged in the development of our naval and coast defense armament to meet with the success that is attending the trials of the new mechanisms. We were told that we were unable to build ships, make armor or construct guns, yet now we have the fastest cruiser in the world, our armor plate has resisting qualities that are unequalled, and our guns are the peers of the best in accuracy and carrying capacity; we must now bring our torpedo boats up to the standard and speeds reached by Yarrow, and then we will be up in every point. The submarine boat that will probably soon be constructed has raised great expectations, which bear all the signs of speedy fulfilment.

THERE has been a long and loud shout of mingled applause and astonishment over the success attained by the electrically driven boat on the Erie Canal. Why there should have been any surprise surprises us, for of all sensible methods that bear practicability upon their very face, the electrically propelled canal-boat takes the lead. These boats are built solely for carrying freight; speed is of a minor consideration, and the usual dangers of navigation are lacking. With mule or steam-engine propulsion four men, to say nothing of the cook, are required for the crew of a boat that is driven day and night. With electricity two men suffice. Thus wages are halved, and surely the power should be supplied more cheaply than small individual engines could do it. So with cheaper power and wages divided by two, it would show a pretty state of things if the method were not a success.

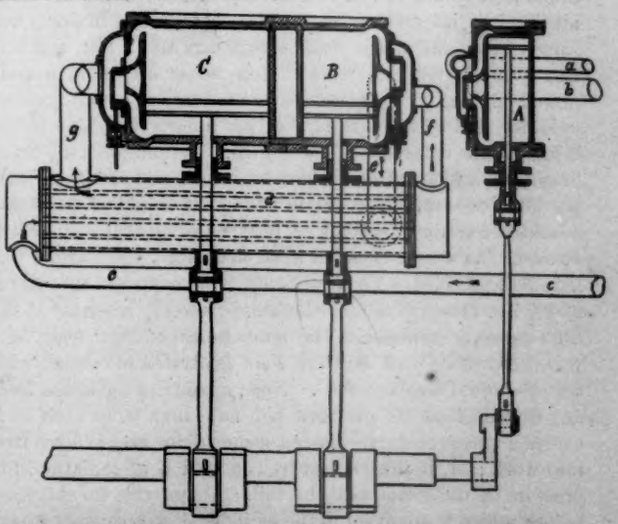
COMPOUND ENGINES.

WE have before us a circular and a letter from Mr. F. H. Wenham, of London, in which he describes a form of compound engine patented by him 30 years ago. In explaining his engine in the circular, he states the general theory on which it was constructed, and, in his letter, he theorizes on some of the more recent practice in the construction of compound locomotives. It will not be uninteresting or unprofitable, perhaps, to go back and see what was done then, and compare the practice of that time with what we are doing now.

In describing his engine, Mr. Wenham says that good economy has resulted from the use of high pressure—steam worked expansively before condensation; but it is well known that in a simple engine expansion can only be carried to a limited extent with advantage, as the practical effect is far below the theoretical value; this arises from diminished volume by loss of heat in expanding. The cooling by radiation may be prevented by steam-jackets or heating the cylinders above the steam temperature. But steam, in common with all gases, by the mere act of expansion falls in temperature with a loss of volume, and its whole bulk is instantly filled with aqueous particles which are thrown down as water.

The object of Mr. Wenham's improvements was, he said, "to maintain the full volume by conveying heat into the body of steam during expansion by the adaptation of heating-chambers through which the exhausted steam passed in its way from the small to the large cylinders. These chambers may either be heated by waste heat from the chimney, by a separate fire, or by means of superheated steam."

The following is an illustration of one of his inverted three-cylinder engines suitable for screw propulsion, which he described as follows:



Steam is led direct from the boiler into the first cylinder *A* through the pipe *a*. The exhaust steam returns by the pipe *b* into a heating-chamber (not shown in the engraving) placed

below the chimney, or heated by a separate fire; the steam was thereon raised to a very high temperature, but before entering the second cylinder it gave up a portion of its surplus heat to the steam on its way from the second cylinder *B* to the third one *C*, as follows: the highly superheated steam from the first cylinder *A* is returned by the pipe *C C* through a set of tubes in the heating-chamber *d*. The exhaust steam from the second cylinder *B* passes into this chamber by the pipe *e* and is then exposed to the exterior of the tubes, and is thereby heated in its passage to the third cylinder *C*, to which it is conveyed by the pipe *g*, and from which it is finally condensed by a surface condenser. The inter-heater for the third cylinder is thus brought close to its work, is not liable to injury from excess of heat, and avoids the necessity of having two heaters.

In the same circular Mr. Wenham illustrates a two-cylinder non-condensing portable engine, the inter-heater of which is placed inside of the smoke-box, and consists of a cylindrical-shaped vessel with tubes extending through it parallel with its axis. The exhaust steam is conducted to this heating-chamber in the smoke-box, where it is reheated, and is thus increased in volume, and is then conveyed to the large cylinder, where it is expanded the second time.

In view of the great amount of ingenuity which has been exercised in the design of compound locomotives of late years, it will be interesting to compare what has been done since Mr. Wenham patented his engine and exhibited it and received a medal from the great Exhibition of 1862, when, he says, "every one was scared at the boiler pressure—from 150 to 200 lbs. per square inch—that he deemed necessary."

When steam expands in a cylinder and does work by acting against a moving piston it loses heat; the loss of heat, too, is in proportion to the work done. If we had a vertical cylinder—say 100 in. in diameter—and a quantity of steam of, say, 200 lbs. pressure and of 388° temperature, sufficient to fill the cylinder one-quarter full, was permitted to flow freely into and expand into the whole volume of this cylinder so as to fill it full, and there was no loss of heat by conduction or radiation, the final pressure would be, roughly stated, 50 lbs., and its temperature would be 298°. Let it be supposed that there is a piston in the cylinder and that it is loaded with a weight of 200 tons, and that when the steam flows into the cylinder it must raise the piston and its load, and that when the cylinder is one-quarter full the supply of steam is cut off and it is then allowed to expand, and will thus continue to raise the loaded piston to the end of its stroke, or as far as the reduced pressure of the steam will permit; it would then be found that there was a greater loss of heat when the steam was doing this work than there was when it expanded in the cylinder without raising a weight. We will not now go into the question of how much heat would be lost as a consequence of raising the load; all that it is intended to make plain here is that in doing this some of the heat of the steam disappears and is lost, and is in reality converted into work. Now, what occurs in a compound engine? The steam is admitted into the high-pressure cylinder, and by its expansive action pushes the piston before it against the resistance of the engine. In doing this the steam loses heat, which is transformed into work, and, consequently, partial condensation occurs in the cylinder unless the steam admitted contains a surplus of heat, or is superheated, as it is termed. As we are engaged in an elementary elucidation, this may be explained. To do this, let it be supposed that steam of 200 lbs. pressure (above the atmosphere) is admitted to the high-pressure cylinder. The temperature of this steam, if it were saturated—that is, if it were generated in contact with water—would be about 388°. Now, as soon as the steam loses any of this heat its pressure will fall—that is, as soon as it exerts a pressure on the piston some of its heat is converted into work; or, if heat is lost by conduction or radiation, the pressure of the steam will also fall. To provide for this loss, before steam is admitted to the cylinder it is sometimes superheated—that is, it is heated without being in contact with water—to a temperature higher than 388°. The steam may, therefore, lose this surplus heat without being very materially lowered in pressure. But there are some serious practical objections in working steam of such high temperature, growing out of the difficulty of keeping the inside surfaces of the cylinders, the piston-rod and valves lubricated. For this reason superheating has never been very generally adopted.

It would, however, seem as though the method adopted by Mr. Wenham, of reheating the steam after it had done its work in the high-pressure cylinder, and after its temperature and pressure are reduced, was not open to the objections to superheating very high-pressure steam.

Mr. Wenham in his letter, to which we have referred, says:

Mr. Lancaster, of the Kirkler's Hall Coal & Iron Works, for the purpose of testing this system thoroughly ran his steam from the high-pressure cylinders into an inter-heater consisting of another boiler, with a separate fire; he informed me that the increase in power and corresponding economy of fuel was most remarkable when this second fire was alight. Unfortunately Mr. Lancaster died without recording the particulars of his experiments.

In discussing the advantage of inter-heaters, Mr. Wenham says further:

If the steam from the first cylinder is expanded through a cold chamber in its passage to the second cylinder, or from that to the third, the result will be a positive loss, as the intermediate receivers will partly act as condensers, and if set under the exhaust will speedily become choked with water. This has been partly prevented by enclosing the inter-chamber with a steam-jacket; but this again affords no economy in the ultimate result, as we must still have external condensation. The steam-jacket of a working cylinder prevents internal condensation, caused by the fall of temperature by expansion from a high pressure to that below the atmosphere, and the consequent loss from alternate heating and cooling of the surface. In the inter-heaters of compound engines the pressure should be obtained as uniform as possible by giving as large a capacity as practicable. As to the capacity of the heating chambers, the rough rule may be taken—make them as large as circumstances will allow; and much the same principle will apply to the heating surface. If this is small, the effect is scarcely appreciable, and water constantly settles in the bottom, showing that there is no increase of volume such as is derived from steam thoroughly dried.

Inter-heaters constructed with straight tubes, with the ends expanded into the tube-plates in the usual way, have been found to be very troublesome from leakage, as dry steam is ineffective in preventing differences of temperature in the parts. Consequently some tubes get hotter than others, causing the joints to leak. If an entire tubular arrangement is used, the tubes should have a considerable curvature, as a horse shoe shape, or coil, or, preferably, the tubes should be attached at one end only, as in a Field boiler, the steam passing down to the bottom through light inner conducting tubes, or outside of these and up in the interior.

The designers of compound locomotives do not seem to have availed themselves of the advantages of inter-heating the steam to the extent which is possible. In the new edition of Wood's book on Compound Locomotives it is said that "the drop of pressure into the receiver represents an actual loss of efficiency, since it occurs by the expansion of the steam without doing useful work."

The authors of this excellent book seem to be a little uncertain of their ground in discussing this subject. In one place (page 54) it is said:

Superheating in the receiver of a compound locomotive is practically impossible unless the smoke-box temperature is above what it should be for good economy in the boiler, for the reason that the steam passes through the receiver when the engine is at speed at a rate that would make it impossible to collect enough heat to re-evaporate all of the moisture in the steam, much less to cause a superheat. . . . . It is true that the temperature of the smoke-box is about 600°, quite sufficient to produce a substantial superheat, if the steam remained in the receiver long enough to permit it; but at 200 revolutions per minute, which is an ordinary velocity for a locomotive, there are 400 exhausts into the receiver per minute. If the receiver is about twice the volume of the low-pressure cylinder up to cut-off, then each cubic foot of steam remains in the receiver about $\frac{1}{200}$ part of a minute, or about $\frac{1}{4}$ of a second, a much too short a time to permit of superheat.

The latter statement seems to be only an assumption. We might argue in the same way about the action of the hot gases in the flues of the boiler. The rapidity of the movement of the gases in the tubes is so great that their period of contact with any given surface it might be said is infinitely short, and yet in that period they do transmit their heat to the water outside. If the steam remains in the receiver too short a time to absorb heat, the obvious remedy is to increase the size of the receiver or its heating surface. Doubtless if a current of steam flows so as to impinge against a hot surface of metal, it will always absorb a very considerable amount of heat, no matter how short the period of contact is. Doubtless, too, the larger the heating surface in proportion to the volume of steam, the greater will be the amount of heat which will be absorbed,

On page 83 of the book from which we have quoted, it is said :

Smoke-box temperatures vary from 400 to 1,200°, according to the forcing of the engine and the length of the tubes. Recently there has been a decrease in smoke-box temperatures, with new designs of locomotives, resulting from the use of larger fire-boxes and longer tubes, and it is probable that smoke-boxes will be run at a lower temperature in the future than they now are ; but in no case will they reach so low a temperature as to remove all value for the purpose of re-evaporating moisture in the steam in the receiver of two-cylinder receiver compound locomotives.

Again it is said on page 276 :

The amount of re-heating in the receiver will vary with the temperature of the smoke-box and the speed of the engine. By using a large copper receiver with a volume not less than three times that of the high-pressure cylinder, such re heating as it is practicable to gain may be had. As the re-heating in the receiver is done by the waste heat in the furnace gases, all the re-heating that takes place is clear gain, and in this way it differs from re-heating by boiler steam.

Mr. Dean, in designing the Old Colony compound engine, seems to have availed himself of the advantage of re-heating the steam to a greater degree than any other designers have thus far done. It seems as though there was here a much-neglected means of economy. If the only difficulty is in getting a re-heater large enough, then it would seem as though it might be worth while to alter materially the shape and dimensions of the smoke-boxes to get room for a re-heater of sufficient capacity. If compound locomotives come into general service in some places and for some kind of traffic—and they probably will—re-heaters would seem to have a very important function to perform in increasing the economy of the engine and in reducing the fuel consumption.

THE SECRETARYSHIP OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS.

THE annual election for officers of this Society will, according to custom and the provisions of its constitution, be held this month. Among the elective officers of the Society is the Secretary. A comfortable salary is attached to this office, and the position gives the incumbent more or less distinction and consideration. The result is that periodically the Society is thrown into a sort of electioneering paroxysm by different candidates for the position and their friends. At present the exacerbation is very severe, judging from the number of circulars issued and the tense state of mind which some of the members appear to be in when the subject of the coming election is mentioned. There are two rival candidates in the field, one the present Secretary and his assistant. With reference to the merits of the contest, or rather the contestants, we do not propose to have anything to say, excepting that a change in the incumbent of the office seems to be very ill advised, unless there is some adequate reason for it.

But it may be said that this sort of Kilkenny fight, coming on periodically, is, to say the least, unseemly, and is another illustration of what seems to be a characteristic of civil engineers—that is, an inability to agree or co-operate with each other. It nearly always happens when any line of action is proposed in this Society that there is at once a declaration of war, and the membership divides not only into two parties, but at times into half a dozen, and, figuratively speaking, they dismember the tripods of their levels and brandish the separate legs, like shillalahs, over the heads of each other.

Speaking dynamically, this is a great waste of energy, which, instead of being employed in useful work, develops into scandal. Now what is the cure? Obviously, the evil is the consequence of the Secretaryship being an elective office. The periodic feline contests precede or accompany the election, Do away with the election, and the occasion of the general row will also be abolished.

In other words, the evil would be cured by making the Secretary an appointee of the Board of Directors instead of an elective officer. This is now the case in the American Society of Mechanical Engineers, and also in the Master Car-Builders' Association. It sounds like a bull to speak of the *belligerent* members of the Society of *Civil* Engineers, but the expression describes an existing fact. For their benefit we reprint the following extract from the constitution of the latter Association. That instrument provides that :

"A Secretary, *who may or may not be a member of the Association*, shall be appointed by a majority of the Executive Committee at its first meeting after the annual election, or as soon thereafter as the votes of a majority of the members of the Executive Committee can be secured for a candidate. The term of office of the Secretary thus appointed, unless terminated sooner, shall cease at the first meeting, after the next annual election succeeding his appointment, of the Executive Committee organized for the transaction of business. Two-thirds of the members of the Executive Committee shall, however, have power to remove the Secretary at any time. His compensation, if any, shall be fixed for the time that he holds office by a vote of a majority of the Executive Committee. He shall also act as Secretary of the Executive Committee."

It will be seen that this provision makes the Secretary the servant of the Executive Committee, as he should be. They are responsible for the conduct of the Association, and should have entire control over the Secretary and his action, and have the power of appointing and removing him. At present the Secretary of the Society of Civil Engineers is elected in the same way as the members of the Board of Directors and other officers are, and he has, consequently, co-ordinate power and, to some extent at least, is beyond their control. His position should be one which would compel him to do the bidding of the Board. The members of it generally are the only persons in the Society who really know whether his duties are satisfactorily and efficiently performed. A membership scattered over thousands of miles cannot, in the nature of things, know how the daily routine in the office on Twenty-third Street, New York, is performed, as well as the members of the Board of Directors, who are frequent visitors, and who are, or should be, intimately acquainted with the business of the Society.

It will also be noticed that, in the provision quoted above, that the Secretary "may or may not be a member of the Association." This was incorporated in it for the reason that it was thought that at times it might be possible to find a better Secretary outside of the Association than could be found in it. It is said that Mr. Forrest, the well-known Secretary of the Institution of Civil Engineers, and perhaps the most efficient person in such a capacity that could be named, was not a member of the Institution when he was appointed. It seems like folly to select a man in the Society for the position who would be less efficient than some other person outside of it.

It is also true that a Board of Directors, who have assumed the responsibility for the conduct of the Society, will be more likely to select a competent person to perform the executive duties of the Secretaryship than a caucus will, composed of

members with less knowledge of the requirements of the office and no responsibility for the conduct of affairs.

The provision of the constitution of the Car-Builders' Association was adopted in 1872, and since then there has been but one change in the Secretaryship, due to the resignation of the first incumbent. The change was made quietly by the Board of Directors, and without the knowledge of the rest of the Society, no electioneering, log-rolling, nor publication of inflammatory circulars, of which the members of the Civil Engineers' Society now receive so many. A new incumbent was appointed at the same meeting at which the resignation of his predecessor was received, and the new appointee has held the office since 1889.

Another contingency is provided for in the constitution of the Car-Builders' and Mechanical Engineers' Association—that is, that the term of office ceases "at the first meeting after the next annual election succeeding his appointment." The object of this provision is to guard against a continuance of an incumbent of the office when there are reasons for a change, merely because no one is willing to assume the responsibility of a removal. By the provisions referred to the Secretary's appointment ends when a quorum of the newly elected Board meets. This provision also minimizes the chances of scheming for the office, because it is not known until after the general election of the Association who will compose the new Board.

By adopting a provision similar to that under which the Mechanical Engineers and Car-Builders have been working for ten years or more, without a single stormy election—to which the Civil Engineers are from time to time subject—the latter might avoid undignified brawls like the one which is now on.

NEW PUBLICATIONS.

THE publishers of *The Railway Master Mechanic* announce that beginning with January, 1894, the name of that paper will be changed to *Railway Engineering and Mechanics*. We invoke for our contemporary, under its new name, the favor of the goddess of good luck, and that its career may be more prosperous than that of most technical newspapers promises to be in the immediate future.

GOLDTHWAITE'S GEOGRAPHICAL MAGAZINE for July to September, which is published at 79 Nassau Street, New York, reaches us with an announcement that, owing to annoyances unavoidable, caused by labor troubles and the panicky condition of the times, there have been delays in getting out this publication, but that, beginning with January, 1894, it will appear regularly.

HANDBOOK OF INFORMATION OF THE RENSSELAER POLYTECHNIC INSTITUTE, Troy, N. Y. 24 pp., 9 × 6 in.

This is a pamphlet beginning with a brief history of the school, followed by a description of its location, grounds, buildings, and courses of instruction. It is illustrated with engravings of exterior and interior views of the buildings, and, we were about to write, of the students, but unfortunately only exterior views of these have thus far been found to be practicable. The purpose of the pamphlet is obvious.

IMPERIAL UNIVERSITY OF JAPAN (Teikoku Daigaku). The Calendar for the Year XXV-XXVI Meiji (1892-93). Tokyo: Published by the University. 203 pp., 7¼ × 5¼ in.

Like most other similar publications, this begins with a historical summary of the University. The next chapter gives the General Regulations for the Colleges, which is succeeded with a description of the courses of study which may be pursued. An appendix contains a statement of the condition of the University during the year and of the plans for the next, and ends with several large folded maps showing the location of the grounds and buildings. All in all, college calendars or catalogues in Japan are not very unlike those here, excepting that the former contain more unpronounceable names and words than ours do.

A FIELD BOOK FOR CIVIL ENGINEERS. By Daniel Carhart, C.E. 281 pp., 7 × 4 in. Boston: Ginn & Co.

This book, the Author says, "is written for students of civil engineering, and to satisfy a demand, often expressed by field engineers, for a manual convenient in size, containing the desired information, systematically arranged, fully illustrated, and easy of reference."

The various chapters treat of Reconnoissance, Preliminary Survey, Simple Curves, Compound Curves, Miscellaneous Problems, Construction, Frogs and Switches. These chapters are succeeded by the usual tables found in such books.

It is of convenient size, bound with a flap, and is clearly and simply written.

THE TRANSITION CURVE, *by Offsets and by Deflection Angles.* By C. L. Crandall, C.E. 64 pp., 6½ × 4¼ in. New York: John Wiley & Sons.

This little book is divided into two parts, in which the Theory and the Practice of Laying out Transition Curves for railroads is discussed. It contains a good deal of tough-looking mathematics, and the casual reader wonders whether it is all needed for the elucidation of the subject, and also how the late Mr. Trautwine would have treated the subject had he written a book on it in his admirably clear style.

The Author says his book is "primarily intended for the use of civil engineering students. It is believed that the complete set of tables given will render the methods at least as rapid and convenient in actual use in the field as the more restricted or approximate ones now in use."

THE MECHANICS OF HOISTING MACHINERY, *including Accumulators, Excavators, and Pile-Drivers.* By Dr. Julius Weisbach and Professor Gustav Herrmann. Translated by Karl P. Dahlstrom, M.E. 329 pp., 5¾ × 9 in. Macmillan & Co., London and New York.

This is a translation of the section on Hoisting Machinery, made from Professor Herrmann's revised edition of Weisbach's great work on Engineering Mechanics. The engravings are apparently made from the original wood-cuts, and are of the usual excellent style characteristic of German technical literature. The different chapters treat of Levers and Jacks; Tackle and Differential Blocks; Windlasses, Winches, and Lifts; Hydraulic Hoists, Accumulators, and Pneumatic Hoists; Hoisting Machinery for Mines; Cranes and Sheers; Excavators and Dredges and Pile-Drivers. All the problems in the book are treated with what seems to be an excessive amount of mathematics, with Greek notation often printed in the smallest and most confusing type. The book is admirably printed on good paper, but will be useful only to those who are well up in mathematics.

ADDRESSES DELIVERED BEFORE THE WORLD'S RAILWAY COMMERCE CONGRESS, *held in Chicago, Ill., June 19-23, 1893, under the auspices of the World's Columbian Auxiliary of the World's Columbian Exposition.* Official Report. 265 pp., 8½ × 6 in. Chicago: The Railway Age and Northwestern Railroader.

The title of this volume indicates its general character. That of the separate addresses and their subjects is not so easy to describe. The subjects are grouped under five general heads: 1, Opening Addresses; 2, Railway Law and Legislation; 3, Railway Management and Operation; 4, Railway Employés; and 5, Railway History and Development. As there were 35 different addresses and papers, we have not room for their titles and the names of their authors even, much less can we convey any sort of idea of the general character of the addresses, which range all the way from the Constitutional Guarantees of Railway Properties and Franchises against Legislative Spoliation to discussions of the merits of Safety Appliances and Methods of Heating and Lighting Cars. Candor compels us to say that the book is somewhat dreary. Many of the papers have distinctly the character of "compositions," written to order or by request, and not because the authors had anything of special value to say. Not a few of the addresses are on subjects on which the authors were not experts, and there are unmistakable indications of what is called "collating" in some of them. An invitation to read a paper at a World's Congress is hard to resist, hence the size of this volume. It is, of course, true and reasonable that when so many distinguished persons are asked to take part in a conference of this kind, that much that is interesting and valuable will

be evolved; but a few of the addresses before us, like the stocks of some railroad companies, are overmuch diluted. As the book contains over 150,000 words, it is filling, but not always satisfying.

THE FIRST STEAM SCREW PROPELLER BOATS TO NAVIGATE THE WATERS OF ANY COUNTRY. By Francis B. Stevens. From the Hoboken Ferry Company, Hoboken, N. J. 30 pp., 9¼ × 6¼ in.

This pamphlet is a reprint from the Stevens Indicator, and describes the experiments and actual performance of Colonel John Stevens in applying a screw propeller and steam power to navigation on the Hudson River from 1802 to 1806. Incidentally a historical sketch is also given describing what had been done in this direction previous to that date. The pamphlet contains a number of very excellent engravings, made from photographs showing the engine, boiler, and propellers which Colonel Stevens constructed at Hoboken in 1804 and applied to a boat at that time. The boat has been twice reconstructed; the third one was sent to the Columbian Exhibition. The engravings show several different views of the engine separate from and several in its position in the boat. Besides describing what Colonel Stevens did, the historical sketch contains much of interest relating to the achievements of other inventors. It is from sketches like this that the history of the future must be made.

POOR'S DIRECTORY OF RAILWAY OFFICIALS. *Eighth Annual Number*, 1893, *Containing Lists of the Officers of all Railways in North America and of the Leading Organizations Auxiliary to the Railway System; Lists of Officers of South American and Hawaiian Railways, etc.* 511 pp., 8¼ × 5¼ in. Compiled from official information. Poor's Railroad Manual, 70 Wall Street, New York.

We are somewhat late in noticing this volume, and owing to the large number of books sent us for review, cannot atone for the lateness of our notice by fully describing the merits of this number. It has grown, of course, in somewhat the same or greater proportion than our railroad system has. It is replete with information, of which it may, however, be said, as the Caledonian did of Johnson's Dictionary, "It is interesting reading, but a little hard to remember." In the circular accompanying the volume it is said that "a new feature now first introduced into this book is a classified index to the leading manufacturers of railway appliances, which is the most complete and comprehensive buyers' guide ever compiled for the use of railway officials. In this guide we have indexed you under numerous headings appropriate to your business, details of which we will furnish you on application." True to their promise, the publishers have indexed "us" under the appropriate title, and doubtless many of our readers will find that they are similarly favored.

THE CORLISS ENGINE, by John T. Henthorn, and ITS MANAGEMENT, by Charles D. Thurber. Edited by Egbert P. Watson. Third Edition, enlarged. 96 pp., 6 × 4¼ in.

As will be seen from the above transcript from its title-page, this book has a sort of composite authorship. Some of the language in it also has a "composite" character, as will be seen from the following extract:

> The gradual development and appreciation of the Corliss system during the past 36 years has grown to such proportions as to trace this Corliss principle in the design and build of a large proportion of the engines used in our manufacturing industries in this and foreign countries, and I may say that its use for maritime purposes is better appreciated to-day, and will be still better in years to come, by the few years of experience that it has been subjected to to determine its value over other systems now in use for that purpose.
>
> During this long period of increasing usefulness, it has been the rise and fall of the most sanguine expectations of many inventors for its honors. Sufficient evidence has been gathered by steam users throughout, I may say, the civilized world, as a criterion of its merits; and this has been established by facts covering economical performance for years rather than by claims based upon theory.

This is a little mixed. The book, however, is of the type called "practical," and for some reason in books of that kind clear, lucid English does not seem to be regarded as essential. The various chapters treat of Steam Jacketing, Indicator Cards, the Governor, Valve-Gear and Valve Setting, Lubrication, the Air Pump and its Management, Care of Driving-Gears, Heating by Exhaust Steam, and Engine Foundations.

PRACTICAL INSTRUCTIONS RELATING TO THE CONSTRUCTION AND USE OF THE STEAM ENGINE INDICATOR. PART I. *General Design and Construction of Steam Engine Indicators. Special Design, Construction, and Use of the* CROSBY INDICATOR, *with Directions for its Attachment and the Construction of Suitable Mechanism for Operating the Drum, together with full Instructions for taking Diagrams, Computing Horse Powers, etc., to which is added complete Directions for Using Amsler's Polar Planimeter, and Professor C. H. Peabody's Calorimeter.* PART II. *By Albert F. Hall, S.B. Brief Article on the Generation of Steam, and Correct Methods for making Engine and Boiler Tests, with full Numerical Applications. Together with Numerical Examples Illustrating Various Ways of Calculating the Steam Consumption from the Diagrams, etc.* 95 pp., 7 × 4¼ in. Boston: The Crosby Steam Gauge & Valve Company.

The above transcript from the title-page of the excellent little book before us is so long that there is little room for other notice. As it is fully descriptive of the character of the publication, it is perhaps unnecessary to add much more. In the preface the publishers say:

> The purpose of this book is to enable the engineer of ordinary ability to understand: First, the design, construction, and use of the Crosby Steam-Engine Indicator. Secondly, to make suitable preparation for applying it to a steam engine, including the mechanism for operating the paper drum. Thirdly, to take diagrams, read them intelligently, and, after some experience, deduce from them such information as to the working of an engine as a good instrument skillfully applied and handled is capable of revealing to the studious and observing mind.

All this the book does excellently well, and we regret that we cannot devote more space to pointing out its merits. Part II is a very clear elucidation of the phenomena attending the generation of steam, the calculations involved in engine and boiler tests, and directions for making them. This little volume is another illustration of the fact that in many cases the best literature on some engineering subjects is found in trade catalogues.

INTERNATIONAL MARITIME CONGRESS. *General Report and Minutes of Proceedings of Second Meeting held at the Institution of Civil Engineers, London*, 1893. Printed and sold by Unwin Brothers, 27 Pilgrim Street, E. C., London. Five volumes. 10¼ × 6¾ in., 46, 196, 144, 113, and 211 pp.

In an Introductory Note to the General Report the following account of the origin and genesis of this Congress is given:

The first meeting was held in Paris in 1889, under the title of "Congrès international des travaux maritimes," and the proceedings were considered so satisfactory that, at the close of the sittings, the members unanimously determined to make the Congress permanent by the appointment of a "Permanent Commission," with its headquarters in Paris.

> This Commission comprises representatives of 13 European countries. The duty of the Commission is to arrange for meetings of the Congress at suitable periods in the different countries of Europe. It was decided in July, 1892, that the second meeting should be held this year in London, and, to give effect to that decision, an Organizing Committee was formed in England, under the presidency of Lord Brassey. . . . The meetings of the Congress for the reading and discussion of papers were held in sections, among which the subjects to be considered were divided as follows: I, Harbors and Breakwaters; II, Docks; III, Shipbuilding and Marine Engineering; IV, Lighthouses, Buoys, Fog-Signals, etc. The Proceedings of the four Sections are published in separate volumes.

We have not time nor space to give even the titles of the interesting papers and discussions thereon in these volumes, but, with the exception of Section III, can only enumerate them. On Harbors and Breakwaters there are 13 papers, and discussions on about half of them. On Docks there are 11 papers, only a few of which appear to have been discussed. On Lighthouses and Buoys there were 10 papers, and on Shipbuilding and Marine Engineering there were the following papers: Steam Communication with the Continent Past and Present, by A. E. Seaton; Ocean Passenger Steamships, by J. H. Biles; a Description of the New Sand-Pump Dredger for the Mersey Docks and Harbor Board, by A. Blechynden; Marine Boiler Construction, by C. E. Stromeyer; and on Shipowners and Shipbuilders in their Technical Relationships, by A. Denny. There is room for regret, both on the part of our readers and the writer, that we cannot dwell on the points of interest in these papers, but it must be remembered that the area of the pages of THE AMERICAN ENGINEER is limited, whereas that of current engineering literature is boundless.

We will only linger on one point more. The style in which these reports are printed is an example which all secretaries might imitate with advantage. The print is long primer leaded, and measures 4 × 7 in. The inside margin is 1¼ and the outside 1½ in., and the volumes are bound so as to open easily. Reading them is thus a luxury.

THE SCIENCE OF MECHANICS. *A Critical and Historical Exposition of its Principles.* By Dr. Ernest Mach, Professor of Physics in the University of Prague. Translated from the second German edition by Thomas J. McCormack. 534 pp., 7½ × 5¼ in. Chicago: The Open Court Publishing Company.

The general character of this book is indicated in the author's preface, in which he says:

"The gist and kernel of mechanical ideas has in almost every case grown up in the investigation of very simple and special cases of mechanical processes; and the analysis of the history of the discussions concerning these cases must ever remain the method, at once the most effective and the most natural for laying this gist and kernel bare. Indeed, it is not too much to say that it is the only way in which a real comprehension of the general upshot of mechanics is to be attained.

"I have framed my exposition of the subject agreeably to these views."

The book may be said to be a history and analysis of the evolution of the Science of Mechanics. Whether or not it be true, as the author asserts, that it is only by an analysis of the history of the discussions from which the present science of mechanics has been evolved that a real comprehension of the "upshot of mechanics is to be attained," his book is nevertheless a very interesting and instructive one.

The subjects treated of in the different chapters are: I, The Development of the Principles of Statics, in their application to the lever inclined plane, composition of forces, virtual velocities, fluids, gaseous bodies, and a retrospect of the development of statics.

II, The Development of the Principles of Dynamics, with an account of Galileo's, Huygens's, and Newton's achievements, and the latter's views of time, space, and motion, and a critique of the Newtonian enunciations. A discussion of the principles of reaction, the concept of mass, and of the development of dynamics is included in this chapter.

III, The Extended Application of the Principles of Mechanics and the Deductive Development of the Science. The separate subjects treated in this chapter are the Newtonian principles, formulæ and units of mechanics, conservation of momentum, center of gravity and of areas, laws of impact, D'Alembert's principle, *vis viva*, least constraint, least action, Hamilton's principle, and some applications of the principles of mechanics to hydrostatic and hydrodynamic questions.

IV, The Formal Development of Mechanics, including isoperimetrical problems; theological, animistic, and mystical points of view in mechanics; analytical mechanics and the economy of science.

V, The Relations of Mechanics to Physics and to Physiology.

The book is well printed, and is illustrated with 235 engravings, mostly diagrams, and has that commendable addition, a good index.

BRITISH RAILWAYS. *Their Passenger Services, Rolling Stock, Locomotives, Gradients, and Express Speeds.* By J. Pearson Pattison. 252 pp., 8½ × 5¾ in. Cassell & Co., Limited.

The character and scope of this book is perhaps best described in its own preface, in which the Author says:

> The subject of railway traveling is alone considered, and that mainly from a statistical standpoint. Particulars of the commercial speed of all the leading British lines are given, followed by a description of the locomotives at present used in express traffic, the gradients over which they run, and the actual work they perform. Prefaced to this detailed description of the various systems is an introductory section dealing in the most general manner with the subject of railway traveling in this and other countries, and commenting briefly on the train services, the rolling stock, and the safety appliances used in passenger trains working not only in this country, but on the Continent, and in the United States of America.

The book is divided into three parts, the first consisting of four sections on Speed and Punctuality, Passenger Rolling Stock; Safety and Safety Appliances; Locomotives, Gradients, Curves, Train Loads, and Train Timing.

In Part II the British lines are described in considerable detail. To quote again, this time from "Explanatory Notes to Part II," the author says: "The length of each system is given approximately, the traveling facilities are described, and punctuality and local train services are discussed. Following this, under the sub-title of Rolling Stock and General Accommodation, the safety appliances, stations, etc., of each company are briefly described."

Locomotive work is discussed under the separate sub-titles of Speed, Gradients, Locomotives, Actual Performances, and under these are considered respectively "the demands made on the locomotive in the way of speed, the contour of the line over which these speeds are to be maintained, the machines actually doing the work indicated in the previous sections, and the manner in which these machines actually perform this work, as illustrated by a very large number of examples observed, personally, in actual daily practice." Profiles of all the lines, and speed recorder diagrams of some of them, and outline engravings showing the principal features of the leading type of locomotive of each line, are given. There is also a tabular statement giving the principal dimensions and weights of different classes of engines used on the respective lines.

In the last section, or Concluding Remarks, the following topics are discussed: The Highest Speed ever Recorded; The Fastest Train in the World; The Race to Edinburgh; Competitive Traffic and Uphill Running.

The book is admirably printed, and is bound so that it opens easily, which is characteristic of most English binding, whereas in reading some American books one often feels the need of a "jimmy" to pry them open.

COMPOUND LOCOMOTIVES. By Arthur Tannatt Woods. Second edition, revised and enlarged by David Leonard Barnes. 330 pp., 5¾ × 8¾ in. Chicago: The Railway Age and Northwestern Railroader.

As the above transcript of the title-page of this book indicates, it is a recast of Professor Woods's former book. The new edition is nearly twice the size of the original, is printed in larger type, and is generally much improved. In the preface to the new edition it is said that "the aim has been to add all important developments since the first edition, and to describe not so much the plans of various inventors, as to place before the reader the actual construction and practical value of compound locomotives that have been built and put into service. . . . There has been added further consideration of the more important functions of compound locomotives, based on analysis of data and indicator cards, which were not available for the first edition. . . . The first 10 chapters have been prepared with special reference to students. Chapter XI. to XX., inclusive, refer more particularly to the different types of compound locomotives, and have been arranged for designers of locomotives. Chapters XXI. to XXIII. are intended to place before the reader an unprejudiced comparison of the different types, and to indicate why double expansion is expected to be more economical than single expansion for locomotives."

The first eight chapters of the book treat of the Distribution and Action of the Steam in the Cylinders. The ninth chapter is on the Starting Power of Compound Locomotives; the tenth on Condensation in the Cylinders; the eleventh, twelfth, and thirteenth on Valve-Gear; the fourteenth on the Effect of the Reciprocating Parts; the fifteenth to the twentieth contain descriptions of different types of Compound Locomotives; the twenty-first is on Starting Gear; the twenty-second on Reasons for Economy, and the twenty-third on Different Types of Compound Locomotives. An appendix contains a variety of data for which no appropriate place could be found in the body of the book. A good index completes the volume, which is well printed, on fairly good paper, and is illustrated with engravings made by a photo-engraving process, which are very good of their kind.

Altogether the book is the best treatise on the subject in existence, but in view of the tentative character of its subject we are inclined to think that a treatise of this kind should have the form of an annual, which each year would summarize the failures and report the successes of compound locomotives. Such a series of books would become a sort of history of the mechanical evolution of compound locomotives, which might be as useful to future investigators as Bulwer's proposed history of human error.

ALBUM AND CATALOGUE *of the Société Suisse Pour la Construction de Locomotives et de Machines.* Winterthur, Suisse. 34 plates and text. 13½ × 9¾ in.

We have received a copy of a new album and catalogue just issued by this Company, which is interesting if compared with the catalogues of locomotive builders in this country, first as an example of this class of publications, and, second, as illustrating the types of locomotives constructed at these works. The plates consist of half-tone engravings printed on heavy plate paper with a somewhat rough surface, and of a different texture from any we remember seeing used in this country. The effect is very good, and is improved by a light buff background, on which the plates are printed. The descriptions and dimensions of the engines illustrated are given on thin sheets opposite the engraving, and are given in French and German.

The first engine illustrated is a small four-wheeled coupled tank engine, which has the walking-beam arrangement designed by Mr. Brown, the former Superintendent of these works. The next plate illustrates an engine of the "type Forney," which resembles closely the locomotives used on the New York Elevated roads. The third is a four-wheeled tank engine with outside cylinders in the usual position. The valve-gear is an Allen straight link worked from overhung cranks on the outside of the back crank-pins. The fourth plate shows a similar machine to its predecessor, but with an outside Walschaert valve-gear. This form of valve-gear is used on perhaps one-half of the engines illustrated. There are several examples of locomotives of the mogul type, some with tenders and others without, the latter having the tanks between the frames and on the sides of the boiler. A peculiarity of some of this class of engines is that the cylinders are placed behind the smoke-box. In the side view of these engines the center of the chimney is about coincident with a vertical center line drawn through the center of the truck. The back axles appear to be behind the fire boxes or immediately below the back portion. This arrangement makes a very compact-looking engine with quite long tubes. In some of them the steam-pipes are carried outside of the boilers, which would not commend itself to American builders. Fig. 11 shows a very neat design and follows American practice very closely. The driving-wheels are about 4 ft. diameter. The foot-board is placed within a few inches of the top of these wheels, and that of the tender and the running-board are all placed on the same line. Consequently the top surfaces of all of these are in a continuous horizontal line, from the back part of the tender to the front of the engine. It gives the engine a very simple appearance, and the method of construction does not seem to be in any way objectionable.

A number of small tramway locomotives, with four and six wheels coupled, are also illustrated; most of them have Brown's walking beam with the cylinder horizontal and elevated above the driving-wheels. This establishment has made a specialty of locomotives for steep mountain roads, which are operated with toothed racks and gears, and a number of such engines are illustrated in the catalogue before us. Some of them appear to be very complicated. There are a great many ingenious features illustrated in the designs in this book, which would require much more space than we can now give to them to describe, and any one who has ever designed a locomotive will be very much interested in studying the ingenious devices which are shown, and for which this establishment has always been noted.

I. The Oriental Republic of Uruguay at the World's Columbian Exhibition, Chicago, 1893. *Geography, Rural Industries, Commerce, General Statistics.* By Carlos Maria de Pena and Honore Roustan, Director of the General Statistics Office. Translated into English by J. J. Rethore. Montevideo, 1893. 54 pp., 6¾ × 10 in., and folded map.

II. Treatise on the South American Railways and the Great International Lines; *sent to the World's Exhibition of Chicago by the Ministry of Foment (?) of the Oriental Republic of Uruguay.* Montevideo: La Nación Steam Printing Office, Calle 25 de Mayo, Nos. 146–54, 1893. 1,252 pp., 11 × 7¾ in.

III. Comparison of English and American Locomotives in the Argentine Republic. 16 pp., 10½ × 5 in.

The title-pages of these books, which have been transcribed above, will give an idea of their character. The first is a pamphlet prepared for distribution at the Chicago Exhibition, and intended to give an idea of the resources and general characteristics of the Republic of Uruguay.

The second, as its name implies, is a treatise on the South American Railways, and embraces the railways in the Republic of Uruguay, the Argentine Republic, the United—or must we now say the Disunited?—States of Brazil, the Republics of Chile, Paraguay, Bolivia, and Peru, the Intercontinental and Interoceanic lines, the Population of the South American States, and a description of the Ports and Railways of the Oriental Republic. The first part of the book is an English translation of the Spanish text, which is given in the latter half. A map of the South American Railway was intended to accompany the volume, but this unfortunately has not reached us.

The third publication is a pamphlet, from which we give some extracts on another page.

Journal of the American Society of Naval Engineers. *Volume V, No. 4, November,* 1893. Published quarterly by the Society, Washington, D. C.

This publication comes to us with a long list of interesting papers, articles, and notes which swell its dimensions to 314 pp. Only a small number of these papers were, however, prepared especially for this publication or for the Society which it represents. The question might be raised as to how far it is judicious for a Society like this to distend its published proceedings with reprints which are easily accessible in other publications. If a Society can make original contributions to the knowledge for the promotion of which it is organized, whatever it can give will be received with open hands and, it may be said, open minds. If it becomes a dealer in second-hand articles it may serve some useful purpose, but can hardly assume a first place among the institutions of learning.

Per I Mercati Coperti (On Covered Markets). By Marc Aurelio Boldi. Published by the Fratelli Centenari, Rome. 7½ × 9 in., 140 pp., paper covers.

In this book Signor Boldi treats the subject of covered markets in all its branches, not only their materials, construction, and architecture are fully considered, but all the laws and regulations in every detail which should govern the administration of the traffic carried on in them. The work is divided into five parts. The first opens with a brief historical account of the rise and development of markets in various countries; next are presented the conditions which should be fulfilled by covered markets to-day, in order to produce the highest degree of usefulness. In the second part, to show what has been done to provide the centers of habitation with covered markets satisfying such conditions, a description is given of many markets erected in Europe in the nineteenth century, followed by a table containing the principal data relating to such markets. In the third part is described, with still greater minuteness, what has been done in Italy. No mention is made of any American markets. France, it is stated, has always taken the lead in these matters, and with regard to the excellence of its covered markets holds indisputably the first place among civilized nations. The Author states that in these descriptions his aim is not so much to make an abstract study of covered markets as to collect all the information possible, especially of a technical nature, which can be of use to those particularly interested in the subject. In parts fourth and fifth are given the results of Signor Boldi's studies. He here presents his views as to the means he considers most conducive to the end of perfection of building and arrangement in every respect. He closes with some remarks on markets as financial investments he had hoped, he says, at the time of beginning the book, to be able to give figures upon which arguments in their favor must be based, but that statistics do not yet furnish such information in a way to serve this end. He has, however, in the course of his own studies and investigations, arrived at the conclusion that covered markets should be classed among those building enterprises which yield a high rate of interest, his opinion being that such interest fluctuates in the neighborhood of 7 per cent. The book is clearly and concisely written. Eight folding plates give views and plans of ancient and modern markets.

BOOKS RECEIVED.

Proceedings of the Twenty-fourth Annual Convention of the Master Car and Locomotive Painters' Association of the United States and Canada, held at Milwaukee, Wis., September 13–15, 1893. 54 pp., 10 × 6¾ in.

Annual Report of the State Geologist of the State of New Jersey, with two large maps, one of the State of New Jersey and the other of parts of Monmouth and Middlesex counties. 367 pp., 9 × 5¾ in. Trenton, N. J.: The John L. Murphy Publishing Company, Printers.

TRADE CATALOGUES.

The number of Trade Catalogues which are sent to us during the past month is so great that we find it impossible to do more than to make a very brief mention of them:

Standard Water-Tube Safety Boilers, manufactured by The Link Belt Machinery Company, Chicago. 8 pp.,

5¼ × 7¼ in. Describes the construction of the boilers briefly, and illustrates them with a perspective sectional view and engravings of boiler fronts. Also gives illustration and description of the Ewart clutch and view of works on last page.

THE CASWELL HOT-WATER CIRCULATOR, for Heating Dwellings, Stores, Greenhouses, Depots, Schoolhouses, etc., with Hot Water by Forced Circulation, manufactured by F. K. Caswell & Co., Hartford, Conn. 8 pp., 5¼ × 8¼ in. The circulator is illustrated and described, and its application to a heater shown.

THE ROBINS LIFE GUARD OR SAFETY FENDER FOR ELECTRIC AND CABLE CARS. By the Robins Life Guard and Manufacturing Company, Philadelphia. 14 pp., 6 × 9¼ in. Illustrated by engravings of the apparatus, some of which show more or less dilapidated individuals in precarious positions on the fender. An improvement in the moral appearance of the persons who are saved would add to the apparent merits of the device. Those shown in the engravings look like tramps, and it is a little questionable whether it might not be as well to run over some of them. A device, however, which will catch tramps will also save honest folks, and that is what this "life guard" is intended for.

NEW UNIVERSAL CUTTER AND TOOL GRINDER. By the Cincinnati Milling Machine Company, Cincinnati, O. 24 pp., 6 × 9¼ in. This publication gives first a good engraving of the machine, the construction of which is afterward described. On the fourth page an engraving, made from a photograph, is given which shows various kinds of cutters, reamers, and other tools which may be ground on the machine. On pp. 6 to 15 inclusive a number of outline engravings are shown, indicating the method of using this machine, with clear descriptions explaining how it is done. Some suggestions with reference to the care and use of the machine and a list of parts, which may be furnished, completes the pamphlet.

THE 3 × 24 FLAT TURRET LATHE, manufactured by the Jones & Lamson Machine Company, Springfield, Vt. 71 pp., 6 × 9 in. This volume contains two very good engravings showing front and back views of the machine described, and descriptions thereof. These are followed by six pages of engravings showing the chucks, slides, tools, and various appliances which are used. Twelve pages of illustrations showing and describing the kind of work which can be done on this machine. A chapter with six engravings showing and describing its evolution and a full description of it follow. Facsimiles of testimonial letters, a list of users, directions for setting up and operating the machine, and a folded plate showing some large specimens of work done on it, with a table of speeds on the back, complete the publication.

THE VENTURI METER, patented by Clemens Herschel, Hydraulic Engineer, made by Builders' Iron Foundry, Founders and Machinists, Providence, R. I., 5¼ × 9 in. This pamphlet is unpaged, but contains about 70 pp. It contains first a description of the Venturi meter, of which it is said in the opening paragraph that "it is named for the Italian philosopher, Venturi, who first called attention, in 1796, to the relation between the velocities and pressures of fluids when flowing through converging and diverging tubes." The description of the instrument is followed by a reprint of a paper describing it, which was read before the Society of Civil Engineers in 1887. Following this is an extract from Mansfield Merriman's Hydraulics on the same subject. The conclusion consists of tables giving the performance of the meter and tests of its accuracy. The book has numerous illustrations, is well printed, and in excellent taste all through.

THE WIDENING USE OF COMPRESSED AIR. By Whitfield Price Pressinger. 7 pp., 5¼ × 9 in. This is a reprint of an article which appeared originally in the *Engineering Magazine*. The uses to which compressed air is put are briefly described, such as for pneumatic dynamite guns, block signaling, raising water, in the use of crude petroleum for fuel, in emptying tanks; in india-rubber factories the hose is removed from the iron mandrels by forcing a current of air under 50 or 60 lbs. pressure between the hose and mandrels, thereby inflating the hose and permitting it to be easily slipped off; for pneumatic riveting machines, cranes, and hoisting machinery, for pneumatic tubes for transmitting mail matter and other parcels, refrigeration and ventilation, the propulsion of cars, for conveying coal culm, the disposal of sewage, for painting buildings, for sheep shearing machines, raising vessels, purifying water, and for steering-gear for vessels.

THE WESTINGHOUSE SINGLE-ACTING ENGINES, COMPOUND, STANDARD, AND JUNIOR. Designed and built by the Westinghouse Machine Company, Pittsburgh, Pa. 109 pp., 7 × 9 in. This is one of the most luxurious catalogues that has come to us for a long time. The cover, printed in a raised and very artistic design, with a buff and brown ground, is a work of art. The engraving, the paper, the printing, the ink, of a bronze color, is all of the most luxurious kind. There is first a general view of the works, followed with a chapter which tells why the Company builds the kind of engines they do, and gives a perspective view of the engine exhibited at Chicago. Very elaborate perspective and sectional engravings follow, with full descriptions of the different classes and their details, advantages, principles, and theory of their construction, their operation, and economy, and a general description of the character and extent of the business. Our brief notice does scant justice to the merits of this volume—which is from the press of Bartlett & Co., of New York—but it occupies all the space that is available.

THE LOCOMOTIVE PROBLEM.

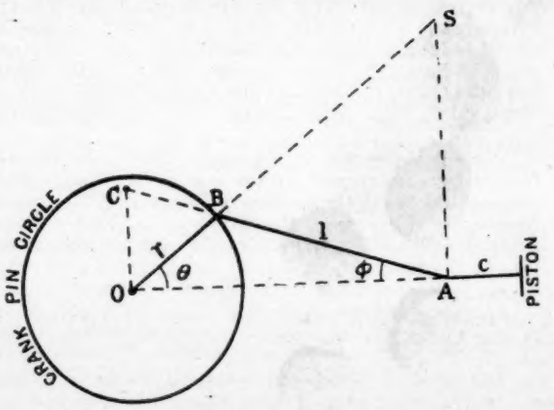
BY RENÉ DE SAUSSURE, C.E., ROANOKE, VA.

IN reading over the last April number of THE AMERICAN ENGINEER, I noticed an article entitled The Locomotive Problem, by C. H. Lindenberger, C.E., Detroit, Mich., which contains evidently a wrong solution of the problem.

Mr. Lindenberger announces this problem as follows:

"Let it be supposed that the stroke of the pistons of a locomotive is 2 ft., the diameter of the driving-wheels 8 ft. and the velocity 60 miles per hour: what is the maximum and minimum velocity of the piston relatively to the earth and not with regard to the locomotive, and when does each occur?"

The author has chosen the usual analytical method for finding maxima and minima—*i.e.*, by writing that the differential of the velocity = *O* for a maximum or minimum; this he has the right to do, although this method is much more complicated in this case than the geometrical solution; but the mistake begins in solving the equation of third degree resulting from this analytical method. The detail of this last calculation is not published in the article above mentioned; and my opinion is that the formula adopted to solve the equation of third degree must have been only a formula of approximation, for Mr. Lindenberger concludes by saying:



"So that the maximum and minimum velocity is not for these parts [the crank-pin radius and the connecting-rod] at right angles, *as some solutions assume*, but is very near that place."

Now, I would ask the author whether he has examined those solutions that "assume," or, rather, whether he thinks that a mathematical demonstration "proves beyond any doubt" or just "assumes." To decide this question, I will take the liberty of recalling here in a few words the usual geometrical solution of this problem:

Let *A B* be the connecting-rod.

Let *O B* be the crank-pin radius.

Let u = the velocity of the piston.

Let ω = the angular velocity of the crank-pin radius, or the angle described by this radius in the unit of time. This angular velocity is constant, since the velocity of the engine is supposed to be constant.

First, it is evident that the maximum and minimum velocities of the piston relatively to the earth occur at the same time as the maximum velocities of the piston relatively to the locomotive; the constant velocity of the engine having only for effect to change one of these maxima into a minimum, when the piston moves backward; so that it is only necessary to find the positions for which the velocity of the piston is maximum relatively to the locomotive.

Second, the point A having the same motion as the piston, will have a maximum velocity at the same time as the piston; we can therefore apply the reasonments to point A instead of the piston. We have now done away with two constants—*i.e.*, the velocity V of the engine and the distance c from point A to the piston. The uselessness of these two constants appears distinctly in the analytical method of Mr. Lindenberger, as they have both disappeared from his equations by the time he has taken the second differential, thus showing that the result is independent of V and c.

Now, supposing that at the start the piston and connecting-rod have the position shown in the figure, let us examine what occurs when the piston moves during a time infinitely short, $d\,t$. The point A moves in the direction $O\,A$ and describes a length $= u\,d\,t$; if we draw $A\,S$ perpendicular to $O\,A$, this length, $u\,d\,t$, being infinitely small and being at right angle with $A\,S$, can be considered as a very short arc of circle described with any radius provided the center is chosen somewhere on the line $A\,S$.

In the mean time, point B has moved on the crank-pin circle. But the length of the motion of B being also infinitely small, and the straight line $O\,B$ being perpendicular to the crank-pin circle, the element described by point B can be considered as a very short arc of circle of any radius provided the center is chosen somewhere on the line $O\,B$.

Now point A and point B are connected together by a solid rod; we know, further, that point A rotates during the time $d\,t$ around any point of $A\,S$, and that point B during the same time rotates around any point of $O\,B$, so that the straight line $A\,B$ rotates around the point common to $A\,S$ and $O\,B$, or around point S. In other words: During the time $d\,t$, the motion of the connecting-rod $A\,B$ can be considered as a rotation infinitely small of said rod around point S.

The element described by point B on the crank-pin circle during the time $d\,t$ has a length equal to $\omega\,r\,d\,t$; dividing the length of this element by the radius $B\,S$ we obtain $\frac{\omega\,r\,d\,t}{B\,S}$ for the expression of the size of the angle described by point B around point S. But the point A also turns around S of the same angle, as we have proved that during the time $d\,t$ the whole connecting-rod rotates around point S. Therefore the point A describes an element equal to this angle multiplied by the distance of A to S, or, $\frac{\omega\,r\,d\,t}{B\,S} \times \overline{A\,S}$.

On the other hand, we have seen that point A describes in the direction $O\,A$ an element $= u\,d\,t$; as point A can have but one motion, these two elements are equal; therefore,

$$u\,d\,t = \frac{\omega\,r\,d\,t}{B\,S} \cdot \overline{A\,S},$$

or,

$$u = \omega\,r\,\frac{\overline{A\,S}}{\overline{B\,S}}.$$

If we draw $O\,C$, or a vertical line, through center, O, until it meets the direction $A\,B$, we have in the two similar triangles $O\,B\,C$ and $A\,B\,S$ the proportion

$$\frac{A\,S}{B\,S} = \frac{O\,C}{r};$$

replacing in the above equation, we have finally,

$$u = \omega \times \overline{O\,C},$$

and ω being constant, this shows that the velocity u of the piston is proportional to the theoretical line $O\,C$, therefore the maximum of u will correspond to the maximum of $\overline{O\,C}$.

After each element of time, $d\,t$, the position of points S and C changes; but it is easy to see that $\overline{O\,C}$ will be maximum when $A\,B$ becomes tangent to the crank-pin circle, or when the crank-pin radius is at right angle with the connecting-rod.

This is not an approximate solution; it means either that the maximum speed of the piston is attained when the connecting-rod is exactly perpendicular to the crank-pin radius, or that the whole cinematical geometry is based upon wrong principles.

Without following all the calculations of Mr. Lindenberger, we can show the same result on his own equation. Keeping the same figures as those used in his demonstration, he obtains the following expression for the velocity of the piston:

$$V + v\,\frac{\sin.\,(\theta + \phi)}{\cos.\,\phi},$$

and he admits himself that V and v being constant, the maximum of this velocity will be reached when the coefficient $\frac{\sin.\,(\theta + \phi)}{\cos.\,\phi}$ is itself maximum. Now, when the connecting-rod is perpendicular to the crank-pin radius or tangent to the crank-pin circle, $\theta + \phi = 90°$ or $\sin.\,(\theta + \phi) = 1$, which is the maximum value for any sinus. Besides the angle ϕ in this position has attained its maximum value, therefore $\cos.\,\phi$ has reached its minimum value. The numerator $\sin.\,(\theta + \phi)$ being maximum, and the denominator $\cos.\,\phi$ being minimum, their quotient is surely a maximum.

In the numerical example mentioned by Mr. Lindenberger, he finds that this quotient equals 1.0540926, when the connecting-rod is at right angle with the crank-pin radius, and that for a certain position very near it this same coefficient has a larger value—1.05464; these two values are so near each other that the error must be attributed to the small errors committed in extracting square roots or in using the trigonometrical tables.

AMERICAN AND ENGLISH LOCOMOTIVES.

(*Continued from page 563, Volume XLVII.*)

Specification of English Express Passenger Locomotive.

LONDON & SOUTHWESTERN RAILWAY.

Tender for Four-Wheels Coupled Bogie Passenger Engines and Tenders.

To the London & Southwestern Railway Company:

Gentlemen: We undertake to build —— bogie passenger engines and tenders and to deliver the same, carriage free, at your Nine Elms Works, London, in strict accordance with your specifications and drawings, and subject to the general conditions hereto annexed, for the sum of £———— for each engine and tender, and to execute a formal contract for the whole of the above or any less number which you may assign to us, if and when called upon by you to do so.

The deliveries to be not less than —— in eight months from the date of order and at the rate of —— per month afterward.

Contractor's Signature.....
" Address.....
Date .....

LONDON & SOUTHWESTERN RAILWAY COMPANY.

Specification of Four-Wheels Coupled Bogie Passenger Engine.

DRAWING NO. 6,815.

Principal Dimensions.

	Ft.	In.
Inside diameter of cylinders	1	7
Stroke of piston	2	2
Length of boiler barrel between plates	11	0
Diameter " " outside	4	4
Length of fire-box shell outside	6	4
Width " " at bottom	3	10¼
Number of tubes	240	
Diameter " outside	0	1¾
Height of center of boiler from rails	7	9
Length of engine frame	30	4
Thickness " "	0	1
Distance between "	3	11½
Diameter of bogie wheels on tread	3	9½
" driving " " } coupled	7	1
" trailing " " }		
Center of bogie to center of driving-wheels	10	9
" driving " trailing "	8	6
" bogie-wheels	7	6

Wheel base from center of leading bogie to center of trailing-wheels 23 0
Height of center of buffers from rails..... 3 6
Working steam pressure.....175 lbs. per square inch.

PRELIMINARY REMARKS.

Where the dimensions are omitted in this specification they will be found fully detailed in the drawings, and these, as well as the terms of this specification, must be strictly adhered to, except in cases where the consent in writing of the Railway Company's Locomotive Superintendent has been first obtained.

IRON.

In all cases where the words "Best Yorkshire Iron" are specified, the same must be wrought iron of the manufacture of Lowmoor, Bowling, Coopers, Taylor's, Monkbridge, or Farnley best iron. In all cases the brand of the manufacturer is to be kept where it can be seen.

BRASS.

The brass, where specified, must be of good tough metal.

GUN-METAL.

The gun-metal used must be composed of copper 8 parts, tin 1 part.

WHITE METAL.

The white metal must be composed of Dewrance's anti-friction metal.

BOILER PLATES.

The barrel, smoke-box tube plate, fire-box casing and throat and back plates of fire-box, also all dome plates and butt strips to be made of the best mild steel of the exact dimensions, both as regards form and thickness, as given on the drawings. To be supplied by makers approved by the Railway Company's Locomotive Superintendent.

Quality —The quality of the material to be that generally known as mild steel plate, and to be free from silicon, sulphur, or phosphorus. The ultimate tensile strain that the plates will stand to be not less than 25 nor more than 30 tons per square inch, and to have an extension of not less than 23 per cent. in 10 in.

Manufacture.—All plates to be made in the most approved manner from ingots hammered on all sides, and, when re-heated, to be rolled truly to a uniform thickness. Both sides to be perfectly clean and free from pitting, roll marks, scale, dirt, overlapping, or other defects. Each plate to be taken from the rolls at a full red heat, and allowed to cool gradually on a flat surface. Each plate is to be sheared to the dimensions given, and in no case to be sent out before being leveled sufficiently true for machining. All plates that are wavy or buckled, or in any way defective, will be rejected, and must be replaced by the makers, free of cost. The maker's name and date of manufacture must be legibly stamped on every plate, and not nearer the edges than 9 in.

A sample or test plate at least 2 ft. square must be sent in by the maker as a sample of what will be supplied in the plates to be made under this contract, together with a complete analysis of the same. This test plate is to be $\frac{1}{4}$ in. in thickness, and from it pieces will be taken for proving in the following manner:

Test.—A piece 6 in. long will be bent over cold until the ends meet each other closely, and no fracture or sign of failure is to be observable in the heel of the bend. Pieces 3 in. wide will also be taken and a $\frac{3}{4}$-in. hole punched through same, which shall stand being drifted cold by taper drifts until it reaches $1\frac{1}{4}$ in. in diameter without the edges fraying or showing signs of fracture.

Samples or shearings from the plates must be tested in the presence of the Railway Company's Locomotive Superintendent or his Inspector, on the premises of the maker, whenever desired.

The barrel and fire-box casing plates to be thoroughly annealed *after* the rivet holes are punched.

The smoke-box tube-plate, throat and back plates of the fire-box to be thoroughly annealed after they have been both flanged and punched.

BOILER BARREL.

The boiler barrel is to be cylindrical and butt-jointed, and is to be made in all respects as shown on drawings; it is to be 11 ft. long between the smoke-box tube-plate and the throat-plate of the fire-box shell, 4 ft. 4 in. outside diameter, and composed of $\frac{1}{2}$ in. plates. The longitudinal joints are to have inner and outer covering strips double riveted, the rivets being placed zigzag. The transverse joint to have an exterior steel weldless ring double riveted. Ring to be turned inside to gauge and to the exact diameter necessary, and then shrunk on. All studs and fittings are to be fixed before the boiler is tested.

SMOKE-BOX TUBE-PLATE.

The smoke-box tube-plate is to be $\frac{5}{8}$ in. thick, the tops and sides of the plate being turned forward $2\frac{3}{4}$ in., forming a flange for the smoke-box, and is to be secured to the boiler barrel by a continuous weldless ring of angle steel well annealed, and supplied by makers to be approved by the Railway Company's Locomotive Superintendent. The ring must be faced, bored and turned on the edges, and then shrunk on the boiler barrel, and is to be double riveted to the same, the rivets being placed zigzag. The tube-plate is to be faced where it is joined to the boiler steel angle. Eight wash-out plugs are to be inserted in the plate, as shown on drawing.

FIRE-BOX CASING.

The fire-box casing is to be 6 ft. 4 in. long and 3 ft. $10\frac{1}{2}$ in. wide outside at the bottom, and to be 5 ft. below the center line of the boiler. The top and sides are to be in one plate $\frac{1}{2}$ in. thick. The back plate to be $\frac{9}{16}$ in. thick, and flanged over to join the covering plate. The front or throat plate is to be $\frac{9}{16}$ in. thick, and flanged over to join the barrel.

All riveted joints in fire box casing to be double riveted. The expansion brackets are to be riveted to the sides of the fire-box shell. The holes in fire-box casing plates for copper stays are to be drilled and then tapped to form a good thread.

RIVETING.

All rivet holes to be punched or drilled $\frac{1}{4}$ in. in diameter, all rivets to be of the best Yorkshire iron with a breaking strength of not less than 22 tons per square inch, and an extension of not less than 30 per cent. in 2 in. Rivets to be $\frac{13}{16}$ in. in diameter before being closed, and to be closed wherever possible by a hydraulic pressure of at least 30 tons, so that they properly fill the rivet holes. The holes in the plates are to be slightly countersunk under the rivet heads, and so punched that when the plates are in the proper position for riveting the smaller dimensions of the holes shall be together at the center of the joint. All holes in the various plates and angle-irons must be perfectly fair with one another, and must not be drifted in any case; should any of the holes not be perfectly fair they must be rimered out until they become so, and every hole must be completely filled by the rivet. The holes in the angle-irons must be marked from the plates and drilled (not punched), the pitch of rivets and lap of joints being in all cases as shown on drawing. Great care must be taken that the plates are brought well together before any rivets are put in. The edges of all the plates are to be planed before being put together. Any caulking which may be required must be done with a broad-faced tool, care being taken that the plates are not injured by so doing.

COPPER FIRE-BOX PLATES.

The copper plates to be of the very best quality manufactured, and to be supplied by makers approved by the Railway Company's Locomotive Superintendent, of the exact dimensions, both as regards form and thickness, as given on the drawings.

The copper plates are to be properly annealed, and a piece taken from each plate must stand the following tests—viz.:

The ultimate tensile strain to be not less than 13.5 tons per square inch, with an elongation of not less than 40 per cent. in 2 in.

A piece 6 in. long is also to be bent double when cold, without showing signs of fracture at the heel of the bend.

Tests to be made in the presence of the Locomotive Superintendent of the Company or his Inspector.

INSIDE FIRE-BOX.

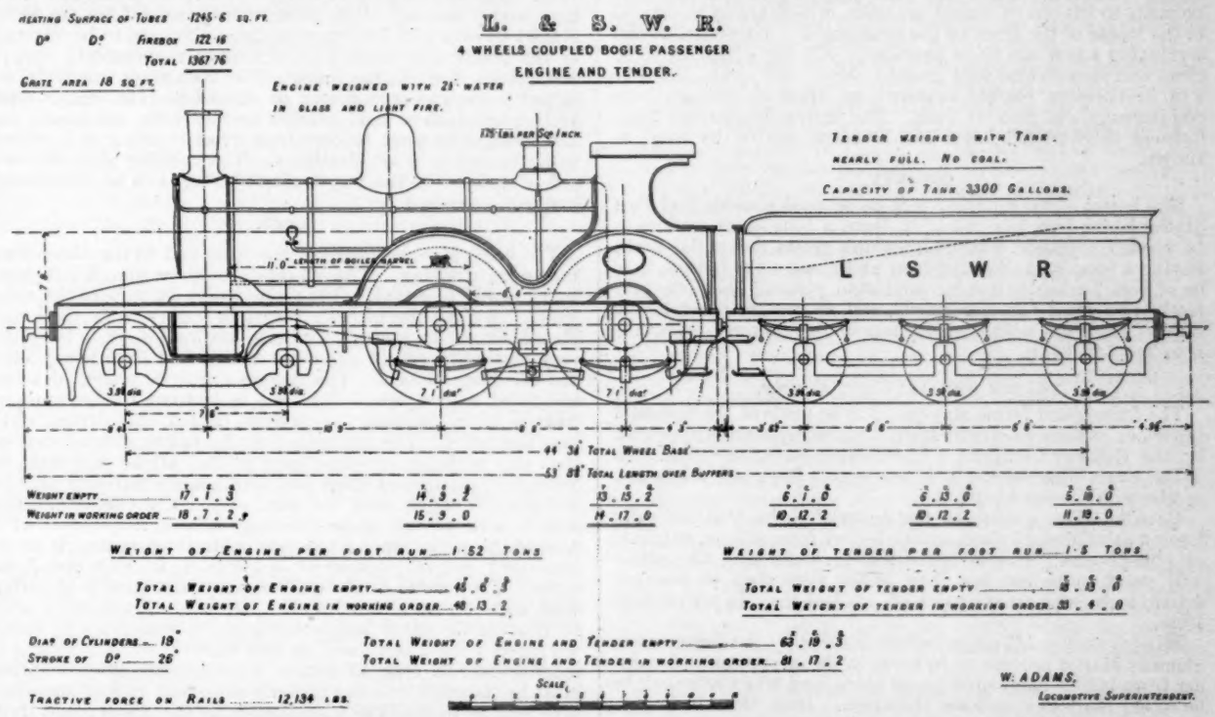
The inside fire-box is to be of copper, 5 ft. $5\frac{9}{16}$ in. long inside at the top, and 5 ft. $7\frac{1}{4}$ in. long inside at the bottom; the height inside at the middle of the box is to be 5 ft. $9\frac{1}{2}$ in., the width inside at the top, 3 ft. 6 in., and at the bottom, 3 ft. $2\frac{1}{2}$ in. The tube-plate is to be 1 in. thick where the tubes and barrel-stays pass through it; the remaining portion is to be reduced by hammering to $\frac{1}{2}$ in. thick, and is to be flanged back to join the covering plate. The back-plate, which must be $\frac{1}{2}$ in. thick, is to be flanged forward. The sides and top are to be in one plate and $\frac{1}{2}$ in. thick; the joints are to have $2\frac{1}{2}$ in. lap when finished, and to be single riveted with $\frac{3}{4}$-in. iron rivets, same quality as used for boiler. All the joints in the copper fire-box are to be hand riveted. Two fusible plugs are to be fixed in the crown of the fire-box.

FIRE-HOLE DOOR.

The ring for the fire-door is to be of the best Yorkshire iron, and is to be circular and of the dimensions shown on drawing. The ring is to be riveted to the fire-box by $\frac{7}{8}$ in. rivets, and is to project $\frac{1}{2}$ in. beyond the edges of the plates, which must be well caulked. The fire-door is to be of cast iron, formed in two halves, and made to slide as shown on drawing. A wrought-iron deflecting plate is to be fixed in the fire-door hole as shown. Also a brick arch in the fire-box as shown.

STAYS.

The outside and inside fire boxes are to be stayed together on all sides with copper stays 1 in. in diameter and 12 threads per inch, made from best soft rolled bars, having a breaking strength of not less than 14 tons per square inch, with an extension of not less than 40 per cent. in 2 in. properly annealed, screwed steam tight into both copper and steel plates, and afterward riveted over. Great care must be taken in cutting off the ends of the stays so as not to injure the threads. The pitch of the copper stays to be about $3\frac{1}{4}$ in., center to center, as shown. Great care must be taken that the holes in the outside and inside boxes are exactly opposite one another. The barrel stays are to be riveted to the boiler with $\frac{3}{4}$-in. rivets and secured to the tube-plate as shown on drawing. The inner copper fire-box is to have eight roof stay-bars of cast steel of approved make of the section shown, and secured to it by bolts which are tapped into the stays only as shown on drawing. The stays are to bear on the top, back and front plates, and are to be slung where shown to the outer shell. The back plate of the fire-box casing and the smoke-box tube-plate are to be stayed together with 11 wrought-iron longitudinal stays $1\frac{1}{2}$ in. in diameter where they pass through the back plate, and $1\frac{1}{4}$ in. in diameter for the remainder of their length; these stays are to have the head bedding on a copper washer and screwed into the fire-box plate; at the other end they are to be secured by a nut bedding on a copper washer on each side of the plate.


L. & S. W. R.
4 WHEELS COUPLED BOGIE PASSENGER ENGINE AND TENDER.
HEATING SURFACE OF TUBES 1245·6 SQ. FT.
FIREBOX 122·16
TOTAL 1367·76
GRATE AREA 18 SQ. FT.
ENGINE WEIGHED WITH 2½ WATER IN GLASS AND LIGHT FIRE.
175 LBS. PER SQ. INCH.
TENDER WEIGHED WITH TANK NEARLY FULL. NO COAL.
CAPACITY OF TANK 3,300 GALLONS.
L S W R
44' 3½" TOTAL WHEEL BASE
53' 8½" TOTAL LENGTH OVER BUFFERS
WEIGHT EMPTY 17.1.3 14.3.2 13.15.2 6.1.0 6.13.0 5.8.0
WEIGHT IN WORKING ORDER 18.7.2 15.9.0 14.17.0 10.12.2 10.12.2 11.19.0
WEIGHT OF ENGINE PER FOOT RUN 1·52 TONS
WEIGHT OF TENDER PER FOOT RUN 1·5 TONS
TOTAL WEIGHT OF ENGINE EMPTY 46.6.3
TOTAL WEIGHT OF ENGINE IN WORKING ORDER 48.13.2
TOTAL WEIGHT OF TENDER EMPTY 18.13.0
TOTAL WEIGHT OF TENDER IN WORKING ORDER 33.4.0
DIAM OF CYLINDERS 19"
STROKE OF D° 26"
TOTAL WEIGHT OF ENGINE AND TENDER EMPTY 65.19.3
TOTAL WEIGHT OF ENGINE AND TENDER IN WORKING ORDER 81.17.2
TRACTIVE FORCE ON RAILS 12,134 LBS.
SCALE
W. ADAMS, LOCOMOTIVE SUPERINTENDENT.

TUBES.

The boiler is to contain 240 brass tubes, of a brand and manufacture to be approved by the Railway Company's Locomotive Superintendent. Each tube is to be $1\frac{3}{4}$ in. outside diameter expanded at smoke-box end to $1\frac{7}{8}$ in. outside diameter for a length of 3 in. and contracted to $1\frac{3}{4}$ in. outside diameter at fire-box end. Each tube is to be No. 11 Standard W. G. thick at the fire-box end for a length of 1 ft. and then to be drawn tapered to No. 13 Standard W. G. thick at the smoke-box end, the taper being on the inside only, the outside remaining parallel. The proportion for the metal in the tubes to be 70 per cent. best selected copper, and 30 per cent. best Silesian spelter. The tubes are to be inspected by the Railway Company's Locomotive Superintendent or his Inspector, and supplied clean, and are not to be covered with paint or any similar coating. The maker's name to be clearly stamped on the outside of each tube. The tubes are to be expanded by a Dudgeon's tube expander, and ferruled at the fire-box end only. At the smoke box end the tubes are to stand through the plate $\frac{1}{2}$ in.

DOME.

The steam dome is to be made as shown on drawing, and to be provided with steel cover. The dome is to be 2 ft. 0 in. inside diameter, and 2 ft. 2 in. high inside, and $\frac{1}{2}$ in. thick. The dome is to be made in one plate and butt jointed as shown. A strengthening plate $\frac{1}{2}$ in. thick is to be riveted to the inside of the boiler under the dome as shown on drawing. The hole for the dome is to be $19\frac{1}{2}$ in. in diameter. A soft steel manhole seating is to be single riveted to the center of the fire-box top, and fitted with a cast-iron cover plate formed in one with the safety-valve columns. The cover-plate and manhole seating are to be accurately faced, so that a perfect steam-tight joint can be made.

REGULATOR.

In the inside of the dome is to be placed a cast-iron regulator in two parts, with flanged joint, to have two valves, main valve of brass and the easing valve of cast iron, to be worked from the back of the fire-box. The steam-pipe leading from the regulator to the smoke-box is to be of hard-drawn copper, No. 6 Standard W. G., $5\frac{1}{2}$ in. inside diameter, and is to have a brass flange brazed on where it fits into the tube-plate; the other end of the pipe to have a brass collar brazed on, and is to be secured to the stand regulator pipe as shown.

WATER SPACE.

The water space between the fire-box and shell is to be 3 in. wide at the foundation ring, and is to be enlarged upward to the dimensions shown on drawing.

FOUNDATION RING.

The foundation ring is to be of best Yorkshire iron, 3 in. wide × $2\frac{1}{2}$ in. deep, and riveted to the inside and outside fire-boxes with $\frac{3}{4}$-in. rivets, snap-headed, 2-in. pitch, to the section as shown on drawing.

ASH-PAN.

The ash-pan is to be placed below the fire-box casing, with movable doors and perforated dampers at the back and front, so arranged as to be worked from the back of the fire-box.

The handles for working the doors are to be placed at a convenient height on the foot-plate as shown. The sides are to be of ¼-in. plates, and the bottom of ⅜-in. plate, of Best Best Staffordshire iron; angle-irons 2 in. × 2 in. × 5/16 in. thick, are to be riveted to the sides and bottom with ½-in. rivets. The ash-pan is to be of the form, and fixed in the manner shown, by angle-irons 4 in. × 3 in. × ½ in., and cottared pins screwed into foundation ring.

FIRE-BARS AND CARRIERS.

The fire-bars are to be of cast-iron, of the form and dimensions shown, and the carriers of wrought iron secured to the foundation ring in the manner shown on drawing.

SMOKE-BOX.

The smoke-box is to be of the form and dimensions shown on drawing. The sides and crown are to be 5/16 in. thick, riveted to the flange of the smoke-box tube-plate. The front-plate is to be in one, and ⅜ in. thick. An angle-iron 2½ in. × 2½ in. × ½ in. thick is to be riveted to the front and side-plates. A hole for the door is to be cut in the front-plate 3 ft. 10 in. in diameter. The door is to be of Best Best Staffordshire iron ⅜ in. thick, protected on the inside with a shield, placed 1⅛ in. from door. Great care must be taken that the door when closed is made a perfectly air-tight joint. The cross-bar is to be made to lift out of forged brackets, which are to be riveted to the inside of the front of the smoke-box. Two handles and a gripping screw are to be provided. All the plates are to be clean and smooth and well ground over. All rivets are to be ⅜ in. in diameter, pitched as shown on drawing, and are to be countersunk and filed off flush. The outside handles are to be finished bright. All lamp-iron brackets are to be fixed as shown.

CHIMNEY.

The barrel of the chimney is to be of good smooth Best Best Staffordshire iron ¼ in. thick, to have a butt joint, and is to be riveted together with countersunk rivets down the back, having a hoop of half-round iron at the top; the bottom is to be of best Yorkshire iron or mild-steel plates ⅜ in. thick, perfectly free from hammer marks, and accurately fitted to the smoke-box. The height of the top of the chimney from rails is to be 13 ft. 2¾ in.

FRAMES AND AXLE-BOX GUIDES.

The frames and frame stay-plates to be made of the best mild Bessemer or Siemens-Martin steel, supplied by makers approved by the Railway Company's Locomotive Superintendent, and of the exact dimensions, both as regards form and thickness, as given on the drawings.

Quality.—The quality of the material to be that generally known as mild-steel plate, and to be free from silicon, sulphur, or phosphorus. The ultimate tensile strain that the plates will stand to be not less than 24 nor more than 30 tons per square inch, with an extension of not less than 23 per cent. in 10 in.

Manufacture.—All plates, whether made by the Bessemer or Siemens-Martin process, to be made in the most approved manner from ingots hammered on all sides, and when reheated, to be rolled truly to a uniform thickness. Both sides to be perfectly clean and free from pitting, roll marks, scale, dirt, overlapping, or other defects. Each plate to be taken from the rolls at a full red heat, and allowed to cool gradually on a flat surface. Each plate is to be sheared to the dimensions given, and in no case to be sent out before being leveled sufficiently true for machining. All plates that are wavy or buckled or in any way defective will be rejected, and must be replaced by the makers, free of cost. The maker's name and date of manufacture must be legibly stamped on every plate, and not nearer the edges than 9 in.

A sample or test plate at least 2 ft. square must be sent in by the maker as a sample of what will be supplied in the plates to be made under this contract, together with a complete analysis of the same. This test plate is to be ½ in. in thickness, and from it pieces will be taken for proving in the following manner:

Test.—A piece 6 in. long will be bent over cold until the ends meet each other closely, and no fracture or sign of failure is to be observable in the heel of the bend. Pieces 3 in. wide will also be taken and a ¾-in. hole punched through same, which shall stand being drifted cold by taper drifts until it reaches 1½ in. in diameter without the edges fraying or showing signs of fracture.

Samples or shearings from the plates must be tested in the presence of the Railway Company's Locomotive Superintendent or his Inspector, on the premises of the maker whenever desired.

All the plates are to be perfectly level and straight throughout, and marked from one template. All holes are to be drilled and rimered out to the exact sizes given, and each bolt and rivet must be turned to gauge, and fitted into its place, a good driving fit. When the frames and cylinders are bolted together, and before the boiler, wheels and axles are put in their places, the accuracy of the work must be tested by diagonal, transverse and longitudinal measurement.

The frames are to be placed at a distance of 3 ft. 11½ in. apart, and to be stayed at the leading end, in front of the driving-wheels, and in front of the fire-box by steel plates and angle-irons, and by a cast-iron foot-plate at the trailing end. The steel plate stays to be planed to the exact width required, and securely riveted to the frames by cold rivets. At the leading end, a steel casting with suitable flanges is to be riveted to the frames at bottom, with ⅝-in. rivets pitched zigzag, and this casting is to be provided with a boss for carrying the bogie center pin. This boss to be accurately turned, and to be planed on the bottom side, to suit the bogie cross-slide. This casting must be perfectly square with the frames. The driving-wheels are to be placed 1 ft. 5 in. in front of the fire-box. The driving and trailing axle-box guides to be provided with adjustable wedges having a taper of 1 in 10, as shown, guide and wedge to be of the very best cast-steel supplied by makers to be approved by the Railway Company's Locomotive Superintendent. The top and sides are to be in one piece, free from honeycomb and all other defects, and the flanges are to be planed all over and fitted to template; they are to be fastened to the frame with bolts 1 in. in diameter, accurately turned and driven tight in the holes. The horn stays are to be attached to the guides as shown on drawing. The frames must be finished with a good smooth surface 1 in. thick, and the axle-box guides must be free from cross-winding and square with the engine in all directions. The rubbing plate on back end of frame for the intermediate buffer is to be of wrought iron case hardened.

BOGIE.

The bogie is to be made of the form and to the dimensions shown on drawing. The wheels are to be placed 7 ft. 6 in. apart, center to center. The frame plates are to be of the same quality as those specified for the main frames, 1 in. thick and placed 2 ft. 7½ in. apart. The axle-box guides are to be of the very best cast steel, of approved make, free from honeycomb and all other defects. The flanges are to be planed all over, and fitted to template. They are to be fixed to the frame by bolts ⅞ in. in diameter, accurately turned, and driven tight into the holes. The frames are to be firmly secured to cast-steel stay with ⅝-in. rivets, zigzag pitch. Great care must be taken that the frames when put together are perfectly parallel and at right angles with the steel stay. The cast-steel cross-slide is to be planed on its rubbing surfaces, and bored out to receive the bogie pin. Each side controlling spring is to be laminated, and is to consist of 16 plates, 2½ in. wide and 5/16 in. thick. They are to be made of the very best quality of spring steel, manufactured from Swedish bar iron. Each spring must be thoroughly tested before being put into its place by being weighted with 2 tons, and on the removal of this weight it must resume its original form. The top plate of each spring must be stamped with the maker's name and date of manufacture, and be to the same specification as the driving and trailing springs. The plates are to be properly fitted and tempered, and are to be prevented from shifting side or end ways by nibs stamped upon them. The buckles are to be sound forgings, and are to fit the springs accurately, and are to be well secured by a short wrought-iron pin driven while hot through a hole in the top of the buckle, and with a hole in the top plate. Through the center of the casting forming the bogie pin a wrought-iron pin 3 in. in diameter is to pass, fitted at the bottom end with a nut and washer; the hole in the stay is to be elongated to allow for the lateral motion of the cross-slide. Each spring cradle is to be made of two Yorkshire iron plates 6 in. deep, 1¼ in. thick, with cast-iron distance pieces riveted between them at each end; these cast-iron pieces are to be provided with means of lubrication, and are to be shaped to rest on the saddles formed on the top of the axle-boxes. The springs are to be coupled to the beams by hooks as shown, the pins through the hooks are to be of steel, and the eyes of the hooks are to be case hardened. The brackets holding the springs are to be of Yorkshire iron, and are to be bolted to the frames with 1-in. turned bolts driven in a tight fit. The whole of the work is to be of the best description, and the bogie, when finished, must be perfectly square and free from cross windings and according to drawings.

MOTION PLATE.

The motion plate to be of the very best cast steel, of approved make, thoroughly annealed, to be ⅞ in. thick, planed

and secured to the frames by ⅞-in. turned rivets, countersunk and riveted cold. The motion plate to be properly faced for the attachment of the slide-bars, and to be as shown on drawing.

FOOT-STEPS AND HAND-RAILS.

Foot-steps and hand-rails are to be fixed on each side of the engine in the manner shown. The hand-rails to be carried round front of smoke-box, and to be 1¼ in. outside diameter. The hand-rail pillars are to be fixed to forged brackets, which are to be studded to the boiler as shown. The foot-steps are to be roughed, and the hand-rails to be finished bright.

PLATFORM AND SPLASHERS.

The platforms are to be of Best Best Staffordshire iron ¼ in. thick, secured to frame as shown on drawing. The splashers are to be of plate iron $\frac{3}{16}$ in. thick, of the form and to the dimensions shown on drawing, the rivets to be ⅜ in. in diameter flush outside. Angle-irons to be 1½ in. × 1½ in. × ¼ in.

CAST-IRON FOOT-PLATE.

A cast-iron foot-plate is to be fitted between the frames at the trailing end, to be of good hard metal, free from all defects. The casting to be fixed to the frames by bolts 1 in. in diameter, to have suitable holes drilled to receive the draw and safety link pins, as shown on drawing.

SAND-BOXES.

Two cast-iron dry sand-boxes to be provided, one on each side, in front of the driving-wheels. They are to be so arranged that the valves can be worked together by suitable gearing from the foot-plate; the valves are to be circular. Sand pipes are also to be fixed as shown; the sand to be led within 3 in. of the rails by wrought-iron pipes 1¼ in. inside diameter. The general arrangement of sand-boxes and gear, and the details of the valves and gear to be as shown on the drawings.

BUFFER PLATES.

The buffer plates are to be of steel, same quality as specified for frames, 7 ft. 11 in. long, 1 ft. 7¾ in. deep, and 1½ in. thick, and are to be riveted to the stays and angle-irons on the inside and outside of frames, as shown on drawing.

BUFFERS.

The buffers are to be of cast iron to this company's pattern. The buffer springs are to consist of three Spencer's No. 119 india-rubber cylinders, to this company's pattern.

The buffers are to be placed at a distance of 5 ft. 9 in. apart, center to center, and at a height of 3 ft. 6 in. from the rail level.

DRAG HOOKS, SCREW COUPLINGS AND SIDE CHAINS.

The drag-hook is to be furnished with Spencer's india-rubber cylinder No. 6, to this company's pattern. The hooks, screw couplings, and side chains are to be of best iron, chain-cable quality, and according to drawing.

(TO BE CONTINUED.)

THE HANDLING OF FUEL ON THE FRENCH, ENGLISH AND BELGIAN RAILWAYS.*

By M. Jullian.

(*Continued from page 568, Volume LXVII.*)

FUEL HANDLING WITH ELEVATORS.

Arrangements of the Paris, Lyons & Mediterranean Company.—The conditions surrounding the coal handling of the Paris, Lyons & Mediterranean Company are almost identically the same as those of the Northern Company, as far as the multiplicity of the quality of the coal is concerned. The management has, therefore, recognized that it is of the utmost importance that the mixture should be well made, and have adopted an arrangement which will be described later on, by which this mixing is done mechanically. They have at present only one of these mixing shops in operation—that at Pont-de-l'Ane, near St. Etienne; another one will soon be built at Courbesac. The cars are run into the station loaded with lumps or mixtures of various kinds of coal, and even with fine pieces, and they are delivered just as they come, though lump and fine coal is given to the engineers in proportions fixed by the engineer in charge of the motive power. It can thus be taken directly from the cars where haste is necessary, or from the coal heaps where such heaps are built up. As a general rule, the Paris, Lyons & Mediterranean coaling stations are platforms, where loading is done with a basket. There are only two plants at which the tenders are loaded mechanically.

Dijon Depot.—Figs. 17 to 21 show the coaling arrangements at the Dijon depot. It is located in two angular spaces next to each other, but separated by a track reserved for coal cars, and bounded on one side of the angle by the track for incoming engines, and the second by a track which is used for the movement of cars. The space between the two car tracks is used exclusively for coal heaps, and will hold about 14,000 tons of different classes of fuel. In the triangular space bounded by the engine track a plant for mechanically handling the coal has been located. The fuel platform is built of masonry; it has a height of 14 ft. 9 in. above the rails, a length of 155.8 ft., and a breadth of 37 ft. 5.6 in. It is cut up by a system of narrow-gauge tracks with a gauge of 1 ft. 7.7 in. arranged in the following manner: A rectangular belt line runs along the four sides of the platform, with a turn-table at each corner; then 10 tracks of the same gauge and parallel to the short side of the rectangle unite the two long sides by means of turn-tables. This platform is bounded by a balustrade in which there are four openings on the side under which the engines run. These four openings are intended for gangways through which the fuel can be dumped into the tender. The gangways are arranged as follows: The opening in the balustrade is formed along the sides and at the heap by a kind of inclined bridge standing at an angle of 60° with the floor of the platform, and made of angle and star iron; a small fixed gangway having a length of 1 ft. 9.6 in., and of an angular form, rests upon the floor of the platform, is riveted to the bottom of the lifting bridge, and stands at an angle of 45° with a horizontal. Finally, next to this fixed gangway there is another which is movable about an axis parallel with the edge of the platform; the second gangway can be lowered or raised at will by means of a chain operated by a small winch located on one of the standards of the bridge and connected by pulley attachments to the center of the opening of the gangways. The connection of the movable gangway to the fixed gangway is made by means of rings, so as to permit a lateral motion which can be obtained by pulling upon the chains fastened to the back end of the movable gangway and the balustrade of the platform.

The coal is carried in lorries holding 1,000 lbs. each, and like those built by Decauville. A steam or lift elevator is located in the narrow space at the left end of the platform for raising and lowering a cage between the level of the depot tracks and the platform tracks. This elevator is operated by a 4-H.P. machine, that gives it a speed of 7.9 in. per second with a filled lorry when going up, and of 9.8 in. in coming down. Finally, at the level of the depot tracks and parallel with the tracks upon which the cars are placed for distribution, two narrow-gauge tracks are located which are connected together and to the track which runs across the elevator by means of turn-tables.

The work of loading the tenders is done in the following way:

The empty lorries are run over a narrow-gauge track nearest the cars, and are filled by the shovelers with shovels; they are then run on the track nearest the platform and on to the elevator, which raises them, one after the other, to the level of this platform. They first run over the belt line parallel to the cars, which are being unloaded, to a scale, where the head shoveler adjusts their loads until they contain 1,000 lbs., and then they are shunted on to one of the cross tracks.

When an engine is run in to be loaded, the shoveler lowers the movable gangway to the tender, takes the lorries and runs them, one after the other, by the belt line up to a point in front of the gangway, empties them, and pushes them down along the belt line, whence they are run out on to the elevator and taken down.

Time Consumed in the Work.—The maximum number of lorries which can be raised per hour is 32—that is to say, the work is so organized that they can lower 32 lorries, fill them, and replace them on the platform tracks in an hour. As to the length of time of unloading the lorries into the tender, it varies from 20 seconds (when the lorry is standing near the gangway) to one minute, when it is some distance off, and it is necessary to run it over double turn-tables.

At Dijon the work on the mechanically operated platform employs 65 lorries and is done by 12 men—six by day and six by night. The average amount of coal distributed for each 24 hours ranges from 150 to 160 tons. In order to facilitate the night service, a brilliant electric light system has been installed upon the platform, where there is an arc light of 250

* *Revue Générale des Chemins de Fer.*

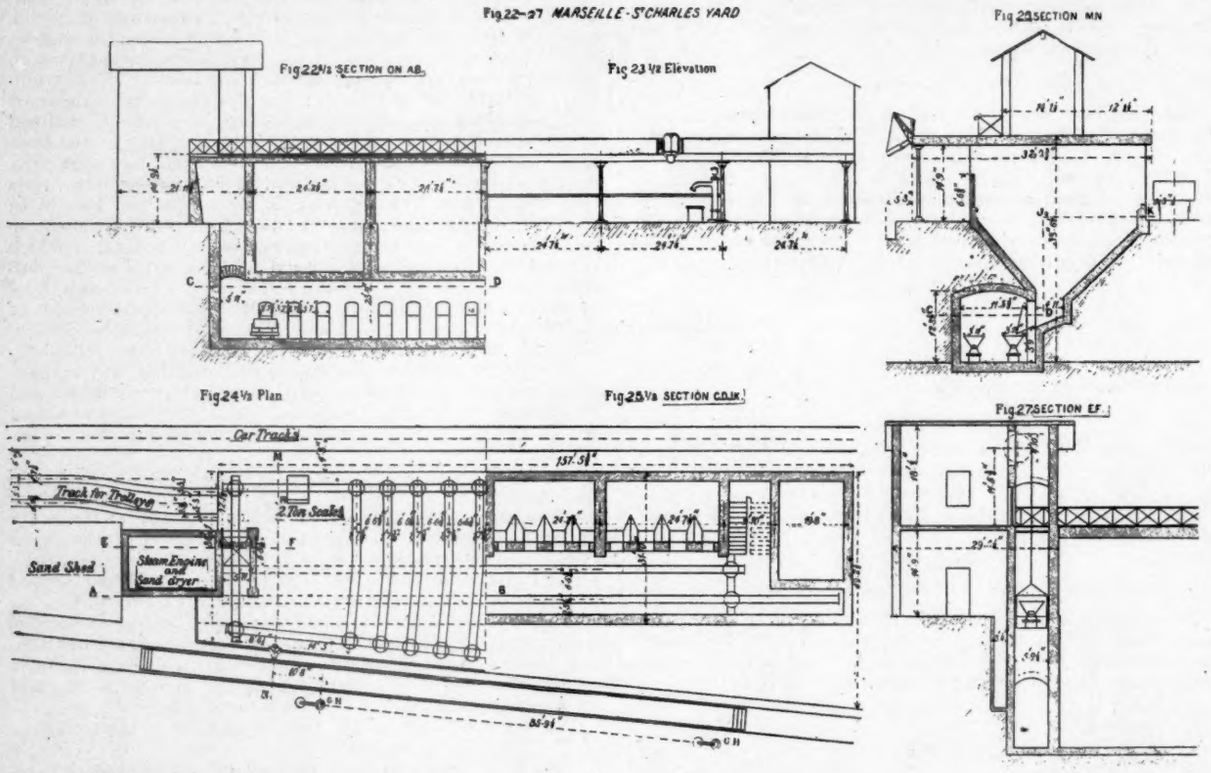
candle power. As we have just explained the manner in which the fuel is taken from the car and loaded upon the tender, and the time which this work occupies, it now remains to speak of those other operations, which consist in dumping the coal into the heaps and taking it from the same. The coal is put upon the heaps with the shovel by means of a wheelbarrow or basket. The cars to be unloaded are run upon the track alongside the coal pile, and further removed from the platforms. Sometimes it is possible to shunt them upon the track which runs directly alongside the pile; this is the case when the pile that is to be built up is not located opposite the platform.

In order to take the coal from the piles and load it on the engines, two methods are used. When that portion which is to be used is opposite a lorry track the shovelers throw the coal upon the floor with a shovel and load it from the floor into the lorries. When the coal is some distance from the lorry tracks, however, they first carry it either in baskets or wheelbarrows to a car which is run as near as possible to the point where the work is done, and it is then hauled on to the track near that of the lorries.

tracks. As there was no place for building up a storage pile, it was necessary to supplement it by a special arrangement, which constitutes the original portion of the plant.

The engine track, as well as that of the cars, was run along the edge on the long sides of the trapezoid, and the platform occupies a space left between these two tracks without any space between, for the location of the narrow-gauge tracks which are used for the movement of the lorries. These tracks are placed parallel to that of the cars, but in the very limited space left between the wall of the elevator building and the wall of the platform built along the small end of the trapezoid. The platform itself, like that of Dijon, stands 14 ft. 9.3 in. above the ground; it is built on masonry dropping down into the ground to a depth of 31 ft. 6 in., and offering the following peculiarities:

Four chambers of equal dimensions are built along the length of the foundation, and serve for storing coal; above the ground these chambers take the form of a parallelopipedon, with a breadth of from 22 ft. 1.7 in. to 27 ft. 1 in., and a depth of 15 ft. 9 in.; below the surface of the ground they are prismatic in form, and the bottom is arranged in the form of a



The cost of loading from the car directly into the tender, including the handling of the cars, runs from $.0668 to $.073 per ton. To this expense of $.0668 or $.073 a general annual expense for the mechanical work of the platform must be added, namely:

Fireman and elevator man, about	$570
Maintenance of engines	76
Fuel and oil	380
In all about	$1,026

A platform has also been built at Dijon for loading engines with baskets in case the mechanical methods should fail for any reason, and for loading switching engines, which cannot always take the different fuels in quantities of 1,000 lbs.

The St. Charles Depot at Marseilles.—Figs. 22 to 27 show that the space available for this coaling station was very limited, and consists merely of a trapezoid whose parallel sides have a length of 49 ft. 2.5 in. and 36 ft. 1.1 in., and a height of 157 ft. 6 in. A plant for the mechanical handling of coal was built upon this trapezoid, and is arranged in almost identically the same manner as that of the Dijon depot. Everything which has been said relative to the Dijon depot applies to this one, and there is nothing to be added unless it is that there are two gangways for distributing to the locomotive hopper. Above the ground they are open on the side toward the car track and enclosed by a plank partition on the engine side. Below these chambers and along the whole length of the foundation there is a vaulted gangway, on the floor of which two narrow-gauge tracks are laid. Each of these four chambers open on to this gangway by means of small windows closed by registers. Finally, a cross track, located at one end of the gangway on the elevator end, makes a connection between the two tracks by means of turn-tables and the elevator, so that cars can be run out into the elevator cage.

The various operations are conducted in the following manner:

Loading Direct from Car into Tender.—As at Dijon, the lorries are run upon a narrow-gauge track nearest the cars to be unloaded, filled, raised by the elevator until they are level with the platform, shunted, etc.

Filling the Underground Chambers.—Each chamber will hold about 300 tons of fuel, so that there is storage capacity in them for 1,200 tons of coal. The cars to be unloaded are run up opposite the openings and unloaded with the shovel.

Loading Engines from Coal Taken from the Vaults.—The lorries are lowered into the vaulted gangway and run opposite the register of the vaults; the shovelers fill them by opening the register to the platform and then run them upon the other rack and have them hoisted, by means of the elevator. From

Fig 17-21 *DIJON-PERRIGNY YARD.*

Fig. 17. Plan

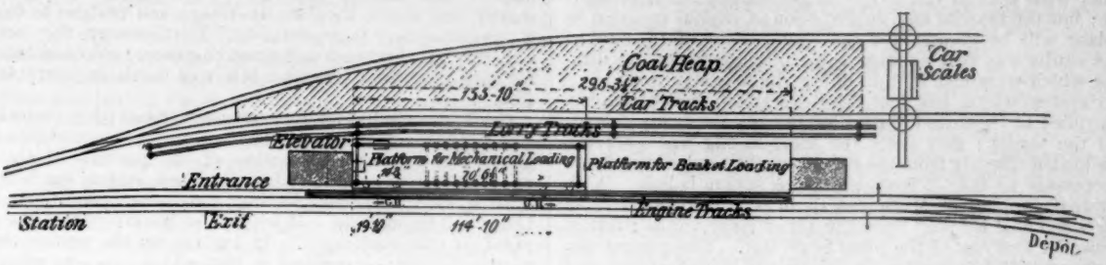


Fig. 18. SECTION ON AB

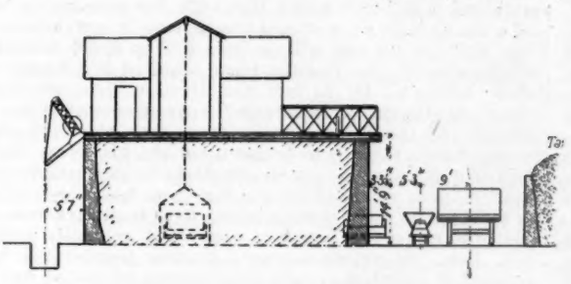


Fig. 19. SECTION ON CD.

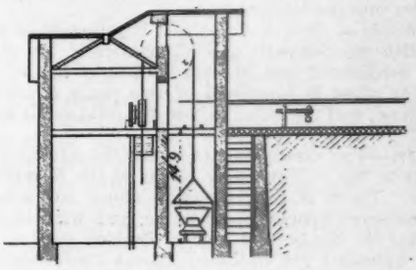


Fig. 20. Plan

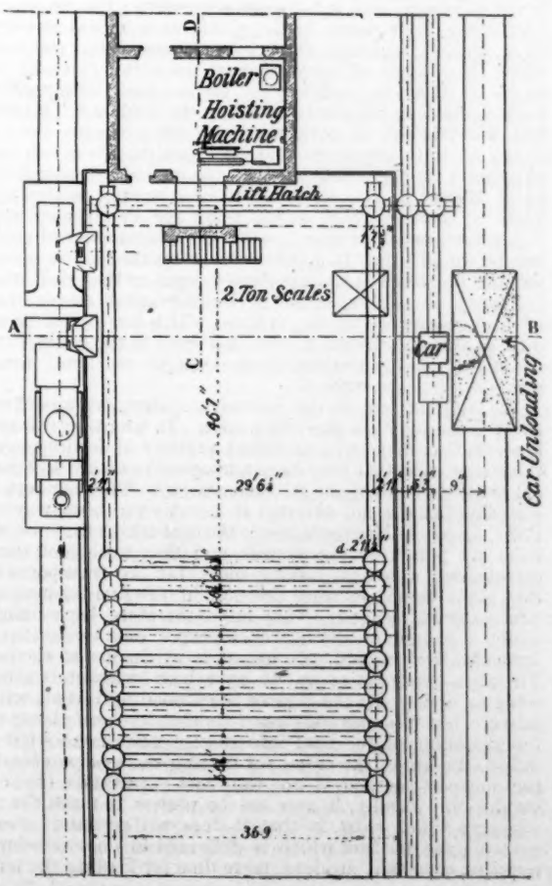
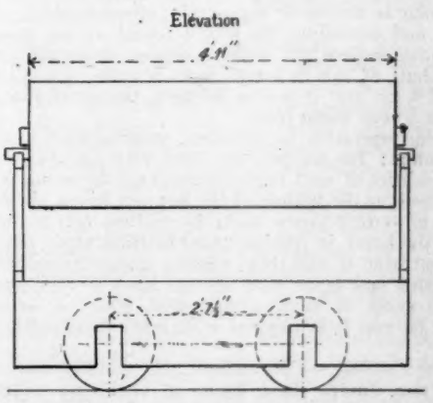
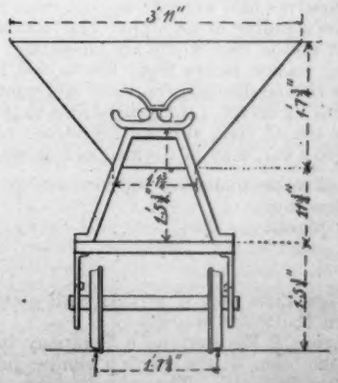


Fig. 21. CAR



SIDE ELEVATION



this time they are handled exactly as if the fuel had been taken from a car.

The work at this station is done with 75 lorries of 1,000 lbs. capacity each, and from 10 to 14 men are employed, six of them working at night. The cost of loading from the car on to a tender, including the handling of the cars, is about $.072 per ton. The expense of operating the motor, its maintenance, together with that of the lorries, is practically the same as at Dijon; but the interest and depreciation of capital invested in the plant will be greater, for the construction of the subterranean vaults was very expensive in consequence of the difficulties which were met with in doing the masonry work.

The system which has just been described, and which has been applied at Dijon and Marseilles, insures a very rapid loading of the tender; they show the same saving whenever the fuel is loaded directly from the cars upon the tender, but when it is necessary to take it from piles, the saving is less. With the system adopted at Marseilles there is still a considerable saving when coal is taken from the set of large vaults; but in this case the first cost of the plant is greater. The general disadvantage which is presented by this system is its first cost, and the fact that it is not readily adapted to the formation of storage piles. The plant could be very much simplified by doing away with the tracks upon the platform, and this simplification would render the system similar to that adopted in England, and would have the advantage of more rapid unloading of the lorries into the tenders.

Mixing Works at Pont de-l'Ane.—It is proposed at this shop to accomplish mechanically and automatically the mixing of the several qualities of coal, and the loading of this mixture on to cars. The plant is composed of two parts, one where the mixing is done, and the other where the mixture is loaded on to the cars.

The Mixer.—The arrangements where the mixing is done is very similar to the subterranean vaults at the Marseilles coaling station. There is a construction along one side that is divided into seven spaces, open above, and with hopper bottoms opening at the bottom into a vaulted gangway. The cars to be unloaded are stationed upon a track located along the upper platform and as near as possible to the opening of the hopper. The bottom of each hopper communicates throughout its whole length with a vaulted gangway by an opening 4 ft. 7 in. wide extending along the whole breadth of the chamber. In this opening and running its whole length is a drum which is driven by a powerful steam engine. Above this drum, and extending the whole length of the gangway, there is a large endless belt, which is driven by the same motor. The upper half of this belt rests upon a series of small rollers which hold it up, and it moves between two small plank partitions with a very slight play.

The mixing operation is, therefore, accomplished in the following manner: The hoppers are filled with a shovel with the different qualities of coal to be mixed, and the motor is started; the wheels at the bottom of the hoppers break up the coal and cause it to drop down upon the endless belt at the same time; and the latter, in passing under the first vault, receives a layer of coal from it, and then, passing under the second, it is covered with a new layer with another kind of fuel, and thus under each vault in such a way that when it arrives at the end of its run it is covered with seven layers of different qualities.

Automatic Loading.—The endless belt, when it reaches the end of its run, dumps these layers of coal with which it is charged into a new hopper, the opening of which is opposite a conveyer. In this way the fuel carried by the endless belt can be dumped into the buckets of the conveyer. The latter raises the fuel to a height of 72 ft. and 42 ft. 8 in. above the tracks of the upper platform. When the buckets reach the top they dump themselves into another hopper, which carries the fuel into the cars standing at the upper platform upon a track parallel to that of the cars which are unloading. The Pont-de-l'Ane coaling station mixes from 800 to 900 tons of coal a day, and uses 16 coal dischargers, three different operations, and a horse, with its driver, for the handling of the cars.

The cost per ton of coal, unloaded into the vaults, mixed and reloaded into a car, may be divided as follows:

Expense of hand-work, including the foreman, per ton.	$.034
Motor, oiling, loading	.004
Maintenance of plant	.01
Total	$.048

This cost is less than that of mixing with a crane, as done by the Northern Railway Company.

The Paris, Lyons & Mediterranean Company have built at Courbesac, in the basin of the Gard, a similar mixer, with a slight modification in detail. The unloading cars are run upon a track over the vaults themselves, so as to be able to unload from two sides at the same time. The expense will, therefore, be a little less. The other parts of the plant are similar to those of the Pont-de-l'Ane. These plants are evidently very carefully designed and well built, and they will insure a thorough mixing at a slight expense; but it is necessary to remark that they can only be applied to particular cases, where they can be built near several lines which furnish the coal to be mixed, and where they are, therefore, not obliged to carry on a supplementary transportation. Furthermore, they are very expensive in first cost and must be guaranteed constant work, for each day that they stand idle will result in a very sensible loss.

Conclusions.—In looking over the various plants which have just been described, we can see that none of them shows a full, general, and complete solution of the problem of the rapid and economical handling of coal. Each system has been built with a view of accomplishing certain set conditions, others being laid to one side. If we look at it simply from the standpoint of ease and rapidity in loading on the tender, the simplest and most economical is that which has been adopted in England, consisting in running the cars either upon the fuel platform or alongside of it, and accomplishing the loading of the tender by means of lorries of 1,000 lbs. capacity, which are run in any direction on account of the absence of tracks on the platforms. From the different reports which have been gathered together it seems that with this process the loading of a tender with a ton of coal can be done in less than one minute, and that the cost will be from $ 05 to $.066, according to circumstances, and that the plant required is not very expensive; taking all things into consideration, therefore, it is necessary to give the preference to the arrangements of the North British and the Caledonian Railway, both of which arrangements permit the cars to be run upon the platform. It is certain that this system has an advantage in the rapid loading of tenders, even when taking the fuel from coal piles—in fact, it is sufficient to make arrangements so as to always have on the platform either fuel lorries or cars which are easily unloaded; but, then, the supplementary handling necessitated by this method of operation results in an increase of cost of fuel as delivered to the tender.

The system adopted by the Paris, Lyons & Mediterranean Company is somewhat similar to the preceding one, though it is not so simple, and is far more expensive; the movement of the lorries, their rising to the platform by means of elevators very sensibly increases the expense of operation, and furthermore the system of tracks located upon the platform is the cause of delay in handling the lorries, and consequently increases the time required for filling the tenders. This system has, nevertheless, an advantage over the preceding one in that it can be built anywhere, and does not require a great extent of ground for the construction of the incline; it even permits, as at Marseilles, the construction of a coaling station upon a piece of ground which is too small for an ordinary station. Yet it is necessary to bear in mind that the amount of coal that can be stored—that is, 1,200 tons—is insufficient to cover the amount delivered at so important a depot as that of Marseilles.

Finally, the Paris, Lyons & Mediterranean system has an advantage over all of the systems which have been examined into, in that the weight of coal delivered to the engines can be controlled, and consequently the weight received from the mines on the cars verified.

We come at last to the Northern system, which differs entirely from the two preceding ones. In adopting this system it seems that they have sacrificed rapidity of loading to a certain extent, and that they have attempted to secure an economical method of mixing at the same station. The Northern Railway Company is not situated in exactly the same way as the Paris, Lyons & Mediterranean; the coal which they use comes from all points of the system, and they could not think of establishing a central mixing plant, for the transportation to this plant would increase the cost of the fuel far beyond the benefits to be derived. They have, therefore, been obliged to adopt a system of mixing on the spot, and think that they have obtained a good solution of it by the use of the cranes. The object does not appear to have been completely attained, since in almost all the depots the unloading is done with the shovel; but it is, nevertheless, true that in those places where the unloading of the coal into storage piles is adopted absolutely, the use of the crane for loading the tenders constitutes the cheapest method, if not the most expeditious that can be employed. Finally, it may not be useless to recall the disadvantages which exist, in that it does not permit of a careful control over the fuel which is delivered to the engineers, and requires, especially at night, more time for loading the tenders.

THE END.

NOTES ON THE MACHINERY OF THE NEW VESSELS OF THE UNITED STATES NAVY.*

By George W. Melville, Engineer-in-Chief, United States Navy.

(Copyrighted by the Society of Naval Architects & Marine Engineers.)

I have been asked by the Committee on Publication of the Society to contribute a paper to this first meeting dealing with the matters covered by the title I have chosen. I presume I have been asked to do this, both because I have been identified with the building of our new vessels almost from the start and also on account of my official position, which naturally gives me opportunities for procuring information not open to all. Although much of what I shall give is not new and has already appeared in print, in reports of the Department and elsewhere, still a *résumé* of the whole subject will perhaps be convenient and save the trouble of hunting up the data in so many places.

The building of our new Navy began, of course, with what are known as the Roach cruisers, the *Chicago*, *Boston*, *Atlanta*, and *Dolphin*, in 1883, but I shall not pay very much attention to these, as, while they were the first of our new ships, there is nothing particularly novel about their machinery, except where it would call for rather unfavorable criticism, and I shall therefore begin my account of the machinery of our new vessels with those which were built under Secretary Whitney's administration.

The earliest of our ships were gunboats and protected cruisers, and in order to get the machinery below the protective deck the engines were of the horizontal type. Later, when the idea of fitting the vertical armor around the cylinders had been advanced, thus enabling vertical engines to be used, we adopted them, and have faithfully adhered to them, except in the single case of the ram *Katahdin*, where the circumstances of the case were such as to compel the use of horizontal engines. I ought to say, however, that our engines all come below the protective deck, so that no vertical armor is used, as is the case in England.

It is hardly necessary for me to point out in such a meeting as this the advantages of the vertical engine over the horizontal, although I would by no means give the impression that our horizontal engines are otherwise than very satisfactory. Indeed, the long cruises made by such vessels as the *Philadelphia*, *Yorktown*, *Baltimore*, and *San Francisco*, leaving the machinery in admirable condition, show that these horizontal engines were very satisfactory.

There are so many able minds working at the problem of the best design for machinery that the matter has been pretty thoroughly developed, leaving very little for an ingenious designer except some change in matters of detail.

Passing for a moment the questions of weight and space for machinery, one of the most important considerations for high-power ships is the matter of economy at ordinary cruising speeds. In the old days, where the maximum speed was perhaps 12 knots, it was a very easy matter to run at 8 knots with at least the same and probably greater economy than at full power, but in our modern ships, built to make 18 and 20 knots, it is a very different thing to reduce the speed to 10 knots. The friction alone of moving the immense pistons and other moving parts of the 16,000-H.P. engine when it is developing perhaps only 1,500, deducts a very large amount from the gross H.P. and leaves the net a very small fraction. Besides the matter of friction, there is to be taken account of the immense cylinder condensation in these large engines running at greatly reduced power and with high grades of expansion. This would reduce the economy very decidedly.

Various methods have been attempted to solve this problem, perhaps the earliest of which was the idea of having two sets of engines on the same shaft, one of which could be thrown out at reduced powers. This was first done, as far as I now remember, in the Italian battle-ships *Italia* and *Lepanto*, but has been since repeated in numerous others and is used in our own vessels, the *New York* and *Brooklyn*. Another method, which naturally suggested itself when the number of cylinders was multiplied in the adoption of the triple-expansion engine, was the cutting out of the low-pressure cylinder at reduced powers and running as a compound engine with the two smaller cylinders of the original triple-expansion engines. This would then work up to somewhere near the full power of the cylinders of that size with a reduced pressure, so that, while not nearly as economical as well-designed triple-expansion engines for the power which was actually being used, it would, nevertheless, be more economical than the large triple-expansion engines working at very much reduced power. This method we have adopted on our armored cruiser, the *Maine*, and I believe it is in use on a Russian cruiser and some other vessels.

The next method which suggested itself is the subdividing of the very large power among three engines instead of two, giving us the triple-screw ship, so that at very low speeds only the central engine need be used, the propellers of the side engines being disconnected and allowed to revolve freely. Of course, in this case there is the loss due to the work necessary to drag these propellers through the water, and to offset this is the gain from saving the friction of running two large engines in a twin-screw ship. The experiments by Chief Engineer Isherwood at the Mare Island Navy Yard in 1874, on the power necessary to turn screw propellers when disconnected and allowed to revolve freely, show that the loss in this way is very slight, and there can be little doubt that this will by no means be equal to the power which would be absorbed in the friction of the large moving parts of two large engines. Then, as has already been pointed out, we shall have a single engine working up to pretty nearly its full power, when the steam economy would be good, while in the case of the two large engines working at very reduced powers the steam economy reduced by condensation would be very low. The first of our triple-screw cruisers, the *Columbia*, has just had her official trials, which have been a great success as far as working at maximum power is concerned. Of course, there has been no opportunity yet to determine the economy of working at reduced powers by the use of a single screw, but by a study of the logs of the *New York* and the *Columbia* for a couple of years we shall be able to form a very clear idea as to which of these methods is the better one for economy.

Still another very ingenious method of combining an engine which shall be fairly economical at full power with one which shall have good economy at moderate powers, is the engine which we have just designed to go in gunboat No. 7 of our Navy, intended for service in a light-draft gunboat. The primary conception of this idea is due to Professor Hollis, of Harvard University, until recently one of my assistants in the Bureau of Steam Engineering, and the subsequent working out has been under my direction and modified to suit all the circumstances of the case.

In this case it was desired to combine as many desirable features as possible, so that the machinery was not only to be economical, but to be very light. With this latter end in view, more than two-thirds of the boiler power is in the shape of tubulous boilers, whose weight, as is well known, is, roughly speaking, only half that of the ordinary cylindrical boiler. The special novelty in the design consists in having the engine designed as a quadruple-expansion engine for full power, taking steam to the high-pressure cylinders from the coil boilers, while the remainder of the boiler power, which consists of two cylindrical boilers, will furnish steam to the first receiver, a reducing valve being fitted so that the pressure in the receiver will be just equal to the pressure of the steam discharged from the high-pressure cylinder. Of course, while this is entirely novel, it is really an extension of the idea which has obtained for some time of exhausting from the auxiliaries into the receivers. This provides for full power. At reduced powers the engines will be made triple-expansion by disconnecting the large low-pressure cylinders, leaving the triple-expansion engines composed of the three smaller ones, and the cylinders have been designed so that they have good proportions for economical working as a triple-expansion engine with steam at 160 lbs. The cylindrical boilers are designed to furnish steam at this pressure, while the coil boilers will furnish to the high-pressure cylinders of the quadruple-expansion engine steam at 250 lbs. pressure. Naturally they can work at reduced pressures, so that either of the cylindrical boilers or any of the coil boilers may be used to furnish steam for the triple-expansion engine at moderate speeds.

This question of economy, at moderate powers, is a more complicated one than would seem to be the case at first sight. Doubtless, we have all thought of the fact that the multiplication of auxiliaries, independently of the main engine on board ship, has involved considerable steam consumption which was not applied directly to propulsion, but, so far as I am aware, the matter had never been considered in great detail until Professor Hollis, then a Passed Assistant Engineer in the Navy, discussed it about a year ago in some lectures he delivered at the Naval War College. In a table which he gives, based on the performance of machinery with which he had had personal experience, showing the percentage of steam developed by the boilers applied to propulsion and to auxil-

* Presented at the New York meeting of the Society of Naval Architects & Marine Engineers.

iaries at various speeds, it can be seen at a glance that, at low powers, the proportion expended in auxiliaries is very large. This, of course, has a very material effect on the economical speed and the steaming radius. In fact, it vitiates entirely the theoretical calculations which are made for radius of action by simply taking the H.P. of the main engine at various speeds, and allotting a certain coal consumption for each H.P, and then working out from the bunker capacity. For one of our ships, where the radius of action has been computed at about 25,000 knots at a speed of 10 knots, I had the calculation more carefully done, allowance being made for steam for the auxiliaries, and found that in reality the steaming radius would probably not exceed 11,000 knots.

In this connection it is well to note a matter which has already been discussed a good deal recently in regard to the desirability of detaching all the auxiliaries from the main engine. As we all remember very well, 20 years ago all the pumps were driven from the main engine. Then, as speeds increased, one pump after another was disconnected from the main engine, until finally it was left with nothing to do except to turn the propeller, and as far as smooth working is concerned, nothing more could be desired. Now it is a question of economy that confronts us, and we are driven to consider whether we have done wisely in driving pumps by simple engines, which are very wasteful in steam instead of from the main engine, which, when well designed and properly managed, is vastly more economical. The relative expenditure of steam in the two types is shown by the fact that some feed-pumps which were carefully tested took 120 lbs. of steam per H.P., while even in our naval engines, which are not as economical as the best merchant engines, we probably got a H.P. for about 20 lbs.

At the recent meeting of the International Engineering Congress at Chicago, Mr. Dickie, of the Union Iron Works, made a very strong presentation of the case for making the air-pump an integral part of the design of the main engine, and I would refer those of you who care to go into this matter at length to his excellent paper. He has given the matter careful consideration, and believes that by a judicious design the air-pump can be made to work at any speeds likely to occur with large engines with as great efficiency as when worked independently and, of course, with a vast increase of economy.

This leads me to speak of a design recently prepared by one of my assistants, Passed Assistant Engineer Frank H. Bailey, U. S. N., of an air-pump specially designed to be run from the main engine of torpedo-boats and other fast-running engines. This pump has already been tested, and under adverse circumstances gave a vacuum of 21 in., at a speed of 1,000 revolutions per minute. This speed is higher than anything that has yet been attempted, although we are now building some torpedo-launches which are to run at a speed of nearly 700 revolutions per minute. These boats will have Mr. Bailey's air-pump.

Thus far I have dwelt principally on the matter of steam economy in our engines as modifying the types and arrangement of cylinders, but I want now to speak with regard to another point which has in recent years become of primary importance—namely, weight and space. Modern machinery which does not give at least 10 H.P. per ton is considered behind the age, and, as we all know, in torpedo-boat machinery the figures run very much higher than this, to as much as 40 H.P. per ton. I think we are all agreed that as long as the demand for reduction of weight is made in a reasonable way every one should accede to it, because manifestly, if we could cut our weights in half for the same power, there would be that much more weight available to be put into guns, or armor or coal for a man-of-war, or into paying freight for the merchantman. It is a question in my mind whether the demand in the past has not sometimes been slightly unreasonable and led to rather unfortunate results, but I am glad to say that in our own service we have been entirely free from any such misfortunes.

The boilers have always been the heaviest part of the machinery, and here naturally the greatest efforts have been made to reduce weight. The one with which we have all become so familiar in the last 10 or 15 years has been forced draft. It seems somewhat odd that we should in effect have followed the lead of our English neighbors in this last introduction of forced draft, when, as a matter of fact, the famous Colonel Stevens introduced it in the early part of this century, and it has been in use for years on the steamboats on the Hudson. Then, too, during our late war, Engineer-in-Chief Isherwood built 19 gunboats of the *Chippewa* class, which were also fitted with ash-pit forced draft. In any case, the practice had fallen into disuse, until it was finally reintroduced by the torpedo-boat builders and then taken up by the English naval authorities. Since then every navy in the world has gone in for forced draft, and to some extent it has been applied in the merchant service also, and, in fact, bids fair to become pretty generally used.

I am a firm believer in the benefits of forced draft when intelligently applied, and have no patience with the people who blow hot and blow cold on the subject (as I have unfortunately been compelled to experience during the last 10 years), who, because an accident occasionally happens with forced draft, immediately say that it is an invention of the evil one and that it ought to be abolished altogether. The same line of argument would probably prevent our using any modern methods in any line of work.

As between the two methods of forced draft in most common use—that by closed fire rooms and by closed ash-pits—I am decidedly in favor of the latter when it can be applied. I make this proviso for the reason that some may at once ask why, if I am a believer in ash-pit forced draft, nearly all of our large vessels recently designed have forced draft on the closed fire-room system. It is simply because in a war vessel with a protective deck and minute water-tight subdivision it is extremely difficult, where there is a number of large boilers, to so arrange the blowers for closed ash-pit forced draft as to ventilate the fire-room thoroughly. This is a point which is sometimes forgotten, but if it is, the fire-room would simply become intolerably hot, and while the boilers themselves will work admirably, the men will simply be killed by the heat. The *San Francisco* of our Navy has ash-pit forced draft, and all who have had experience on her and on other vessels speak in the highest terms of praise of the greater facility, convenience, and comfort which attends this method.

It is to be noted, also, with this method of forced draft, that when there is any care at all taken in the fire-room to keep the grate-bars covered, leaky tubes in the combustion chamber are unknown, while with the closed fire-room forced draft they are not at all uncommon.

I shall forego the temptation to dwell on this matter of leaky tubes, merely saying that we have been very fortunate in escaping almost entirely every trouble of this kind, which I attribute, in a large degree, to the fact that we have not attempted to get too much work out of our boilers, and will pass on to speak of another method of forced draft which is very old, but which has only been used on board ship within the last year or two. I refer to the matter of high smoke pipes. Tall chimneys are the most common method on shore for getting a strong draft, but prejudice or conservatism has until recently prevented the application of this practice to use on board ship. The Messrs. Denny, of Scotland, well known for their enterprise in all matters relating to shipbuilding, were the first to call prominent attention to this matter by a vessel built by them called the *Scot*, which had smoke pipes 120 ft. high above the grate and no other attempt to force the draft. I do not know that any accurate experiments have been made with smoke pipes of steamers to determine just what the increase in draft is for each increase in height, but it has been repeatedly stated that, roughly speaking, we may assume 10 ft. of additional height to be equivalent to an additional one-eighth of an inch of air pressure. It can readily be seen, therefore, what a benefit an additional 40 ft. of height would be.

Taking the suggestion made by the *Scot*, when we were designing the *Brooklyn* and the *Iowa*, I asked to have the smoke pipes made 100 ft. high, in which I was heartily seconded by the Chief Constructor of the Navy; but it will perhaps surprise you to learn that our professional opinions recommending this matter came very near being overturned by the artistic sense of a gentleman in the Navy Department, who was entirely ignorant of technical matters, but who thought that the vessel's appearance would be spoiled by these high smoke pipes. He so represented the matter to the Secretary that the latter required me to submit the reasons why I desired to use these high smoke pipes. This I did. As showing the general feeling on this subject, I need only call attention to the fact that the *Campania* and *Lucania* have smoke pipes 130 ft. high, and no other method of forced draft, and I may say that all our new vessels are now being built with pipes of much greater height than formerly obtained.

Another method of forced draft which is now coming into vogue is that known as induced draft, where, instead of closing in the fire-room or the ash-pit and forcing air in, the products of combustion are exhausted from the chimney by large fans. Of course this is only another way of getting the same effect that we get by the use of the steam jet, and with which we have all been familiar for many years, the advantages in this case being that there is no loss of fresh water, which is a precious commodity on board ship. At a hasty glance one would not be prepared to expect very much from this method, but the experiments which have been making for some years

past in England by Messrs. John Brown & Co. seem to show that this method is very promising, and I understand it is to be fitted to some or all of the large vessels which are now building for the International Navigation Company.

The discussion thus far of reduction of weight assumes that the boilers themselves are not changed materially otherwise than for the fitting of the forced draft appliances, but the question has been a very vital one for some time past, and is now of extreme importance whether we shall not entirely abandon the present types of boilers and adopt a very much lighter one by using what are called coil or tubulous boilers. This matter has been discussed so much by so many able minds, that it is unnecessary for me to go into the matter at length here. We all know the great advantages of these boilers in the way of immense reduction of weight, safety against disastrous explosions, rapidity with which steam can be raised, absolute safety against injury from any amount of forcing, and the ease with which, if necessary, a boiler can be removed and replaced. Almost the only objection appears to be the fear that they will not be durable, because of the fact that they are composed almost entirely of very thin tubes, and our experience with these tubes in ordinary boilers has not been such as to lead us to expect a very long life from the coil boilers. However, some coil boilers have been in use for five or six years without showing appreciable deterioration, and a few have been used with fresh water entirely for more than 10 years.

We are treating this matter on a large scale on the *Monterey*, where we have four coil boilers of the Ward type in connection with two cylindrical boilers. These boilers have given great satisfaction in their trials, and the cruise of the *Monterey* will demonstrate the matter of their durability. I may say that, in my opinion, if the experience with the coil boilers on the *Monterey* and on other sea-going vessels should prove to be entirely satisfactory, it will only be a short time until the cylindrical boilers will be almost entirely displaced.

While on this question of weight, we must not forget the engines themselves, where the weights have also been very materially reduced. As we are all well aware, this has been due to three causes: an increase of steam pressure, an increase of piston speed, and the use of stronger materials. Piston speeds have more than doubled in the last 15 years, and our larger vessels are now running with piston speeds of about 950 ft. per minute, while some of the smaller ones, like the torpedo-boats, are designed for a piston speed of over 1,000 ft. If materials should go on improving so that we can reduce the weight of our reciprocating parts, I see no reason why piston speeds should not be increased still more, which, of course, would result in still further reducing weights. If we adopt the coil boiler generally we shall also carry very much higher steam pressures, because we already are carrying pressures of 250 lbs. in some of our torpedo-boats with great success. We have greatly reduced the weight of most of the engines by the use of forged steel for piston and connecting-rods, valve-stems and shafting, and cast steel for pistons, valves, bed-plates, and frames, but there does not at present seem to be much prospect of displacing cast iron as the metal for cylinders. If this should come about, we could still further reduce our weights, and, if nickel steel should within the next 10 years become as commonly used as mild steel is now, we would have a big reduction in weight all around. In fact, these questions of high piston speeds and better material hang together for the reason that the limit to piston speeds is now placed by the weight of the reciprocating parts, whose inertia will be so great after passing a certain speed that for the early part of the stroke the piston would be giving out no work, but simply be dragged around. If the reciprocating parts can be reduced in weight, of course the speed can be increased until the limit is again reached.

One matter which has been of great interest to all engineers has been the coal consumption on full power trials. We are all very familiar, doubtless, with the claim we constantly hear that a good triple-expansion engine with high-pressure boilers gives a H.P. for 1½ lb. of coal. Our own results have never approached this, and estimates of the coal burned on trial trips also tend to disprove it. Finally, we were able on some of our trials to get thoroughly accurate results with the assistance of the contractors, by having the coal weighed in bags of 100 lbs. each, which could be counted as they were emptied and then again counted after the trial was over. In another case a supplementary coal consumption trial was made with half the boilers, and every effort was made to keep the conditions exactly the same as on the full power trials, in that the air pressure was the same and the engines were run so as to work off all the steam formed. As a result of these trials we found that the consumption for full power was more than 2 lbs., and in some cases as high as 2.6 lbs.

In one of my Annual Reports to the Secretary of the Navy, I called attention to the cause of this difference between the economy of war vessel machinery and that of merchant vessels, and we happened to have very reliable data which had been published of the performance of a particularly economical merchant vessel, which was tested by a committee of the English Institution of Mechanical Engineers under the superintendence of Professor A. B. W. Kennedy, F.R.S. I may call attention to the fact that in this ship, the *Iona*, the boiler has a ratio of heating to grate surface of 75 to 1, which I think tells the whole story. In our war vessels we can never exceed a ratio of about 35 to 1, and then at full power we burn a very much larger amount of coal per square foot of grate, thus making our up-take temperatures very much higher than they were on the *Iona*, so that a large amount of heat must have gone up the chimney without doing any useful work. I may say that these coal consumption tests at full power were the first that had ever been made, and I have not learned of any others having been made since. It of course involves considerable trouble and some expense, and it is only right that the Government should be the one to meet the expense, for the information was certainly of great value.

Another matter which has attracted considerable attention in connection with the trials of our new vessels has been the correction of the H.P. calculated from the indicator cards based on the standardization of the indicators.

The early vessels for our Navy were contracted for with the understanding that they were to develop a certain H.P. The contractors felt that with an agreed steam pressure to start with and known sizes of cylinders they could confidently guarantee that they would develop a certain H.P., but we had at that time no reliable data on which to base our speeds, all our information being of foreign ships, and, while I do not for a moment pretend to say that their trials are not conducted with every effort to secure fairness, we, of course, did not know all the circumstances, as we have since about our own ships, and so might be pardoned for feeling a little uncertain. In connection with the contract it was provided that for each H.P. in excess of the guarantee there should be a certain premium, usually $100, and for every H.P. below the contract requirement there should be a fine of the same amount. This made it very important that the H.P. should be determined accurately.

Experiments which had been made to compare different indicators had shown that no indicator is absolutely accurate at any pressure, and, while those well made did not vary a great deal, there nevertheless is a difference which is worth considering, because in the case of a large engine it will make a very decided difference. In one of the earliest of our large ships the H.P. without correction was over 10,000, while when the corrections were applied it was reduced to slightly less than 9,000. This naturally created a great deal of dissatisfaction on the part of the contractors, but it was due entirely to the defects of the indicators which were used, some of which were as much as 20 lbs. different from the assumed scale at the higher end of the range.

This case and one or two others called the attention of contractors to the matter, so that when purchasing indicators to be used they sent them to the New York Navy Yard, where we have the most elaborate and accurate testing apparatus in the world, and they declined to receive any indicators where the errors were more than a certain amount. The makers of indicators, stimulated by these requirements, have faced the problem manfully, and I am very glad to say that there has resulted a very decided improvement in the accuracy of the springs. In fact, not long since 72 springs were purchased from one maker under a guarantee that the error should nowhere exceed 3 per cent., and out of the 72 only seven had to be rejected, and in these the error was really very small and at the lower end of the scale, where the value in percentage of a given error in pounds is of course greatest. For use on a trial trip these indicators would have been extremely satisfactory, and the error was remarkably uniform.

It has sometimes been sarcastically remarked by persons interested in this subject that the indicator corrections are always disadvantageous to the contractor. This is not strictly true, although it is almost always so, but the reason is perfectly simple I think, and I think we can all understand just why it should be so. Let me say at once that I believe the indicator makers have always worked with an honest desire to have their instruments as reliable as they possibly could be. The errors which exist are not due to carelessness of manufacture, but simply to the conditions of the case, which preclude the possibility of absolute accuracy. Recognizing that this was the case, we can readily understand why the indicator makers should have made the instruments so that the error should be on the side of giving a larger H.P. than the true

one, because that is what everybody wants. These Government tests are almost the only ones with which I am acquainted where there has been any effort made to apply the indicator corrections. In other cases the indicators have been standardized, and as long as the error did not exceed a certain amount, they were taken as correct and the H.P. worked out accordingly. As both manufacturers and owners desire to have engines make as large a H.P. as possible and show as low coal consumption per H.P. as possible, it was only reasonable that, as a variation from strict accuracy was impossible to avoid, it should have been on the side of showing the larger H.P. At the risk of wandering a little from my subject, I may just say in this connection that we have been criticised for our method of testing indicators, on the ground that the conditions were not absolutely identical with those under which the indicator was used. This, of course, is true, as nobody has yet been able to suggest a method of testing the indicator which will enable any record to be made for comparison when it is working as rapidly as it is when attached to an engine making 300 or more revolutions per minute. But, on the other hand, the natural answer to this objection is that the modifications of the old Richards indicator by the various modern types came about, because at high speeds the indicator did not give reliable records, and the claim has always been, and still is, so far as I know, that while the modern indicators are thoroughly reliable at high speeds, they are equally so at low ones. If our method of test is not thoroughly satisfactory, it is incumbent on the indicator makers to show at how low a speed their indicators cease to give accurate results.

I may say in this connection that one of the young officers of the Engineer Corps, who had a great deal of experience in this work of testing, began a series of crucial tests at the New York Navy Yard to determine whether there was any error in the methods we had been using, although neither he nor any of the rest of us who had studied the matter deeply believed that there was any error. Orders to other duties took him away before he was able to complete his experiments, but he had carried them far enough to satisfy him that the method employed is entirely correct.

It may possibly not seem strictly germane to the title of this article to bring in the matter of speed trials, but I do so merely to call attention to a method which I had the honor to bring to the attention of the Navy Department, and which was unanimously approved by the Board on Construction of that department, and was used with great success in the trial of the *Bancroft* early in this year. It consisted in a series of progressive trials for the purpose of standardizing the screw and determining accurately the number of revolutions corresponding to a particular speed. Then having laid a curve to show the relation of speed to revolutions, the vessel could be taken to sea anywhere and the continuous endurance trial run off and the speed at once determined as soon as the average revolutions for the entire period were known. Doubtless many of you are aware that the fast Argentine cruiser, the *Ninth of July*, was tested in this way, and I believe several other foreign vessels also have been. This method enabled the speed to be accurately determined with less difficulty than any other which had been suggested. Patent logs are out of the question, and the run over a long course, which the department is now using, involves the attendance of a very large staff of observers and several ships besides the ship which is making the trial. In the case of trials by the standardized screw method, no other observers are needed than those on the ship itself.

The objections to the trial over a long course occur at once to any one who gives much attention to the matter in the difficulty of laying out the course accurately in the first place, and then the fact that everything which may go at all amiss operates against the contractor. One of the great advantages of the standardized screw method, is that in case the performance of the vessel improves from the very beginning the trial may be prolonged an hour or two, and then any consecutive four hours taken as the one on which the record will be based. Of course, it goes without saying that, if the last four hours of the trial are better than the first four, the Government is getting a ship whose excellence has been demonstrated more conclusively than by the performance of the first four hours. An additional advantage of this standardized screw method, is that the progressive trials over the measured mile enable data of great value to the designers of both hull and machinery to be obtained in getting the relation of H.P. to speed at the various speeds run.

Again, at the risk of being considered somewhat away from my subject, I think it may not be amiss for me to say a word which is based on the matter of economy of machinery at low powers of which I have already spoken. This is a design for an economical peace cruiser. I think all who have studied the matter carefully cannot fail to be struck with the idea that it is a mistake to build small vessels of very high speed for duty as cruisers. I mean vessels of, say, 1,500 to 1,800 tons displacement, designed to make 17 or 18 knots. The machinery necessary to produce this power occupies so much available weight that the amount left for coal is relatively small and the radius of action is very limited. These vessels very rarely in peace time are called on to run at a speed anywhere near their maximum, so that as a matter of fact, during their entire lives, barring a war, they are simply carrying around a large weight of engines and boilers which would be useful in an emergency, but which as things actually go are entirely useless.

Now, in case of war, these vessels are not sufficiently powerful to fight any real war vessel, and they are not fast enough to capture any very valuable merchantman, even leaving out of consideration the fact that no vessel would remain under the flag of one of the belligerents in time of war.

It would seem, therefore, that it would be an economical thing for the Government to build a number of vessels which should be intended entirely as peace cruisers, and which in time of war would be laid up. The office of these cruisers would be to go around and show the flag, to look after the interests of American citizens abroad, and in case of necessity, as happened recently at Honolulu and elsewhere, to land troops. Consequently, they should be able to carry a relatively large crew, and should have as large coal capacity as possible.

Now it seems to me that a vessel of about 2,500 tons displacement, with engines of, say, about 1,500 H.P. for full power under forced draft, would fulfill these conditions admirably. This would give us a speed of about 12 or 13 knots at full power under forced draft, so that with natural draft at full power she could steam with great economy at 8 or 9 knots. The coal capacity would be about 675 tons, and, as the arrangement of auxiliaries could be designed with special reference to economy, she could be safely put down for a radius of action of about 13,000 knots at a speed of 9 knots. I would by all means have such a vessel sheathed, echoing most heartily the efforts which my good friend, Chief Constructor Hichborn, of the Navy, has been making for so many years. The boilers and engines of this vessel would be specially designed with regard to the maximum economy at cruising speed, and I believe that a dozen such vessels would save enough during their career to more than pay for themselves.

METHOD OF MANUFACTURING WELDLESS CHAINS.*

By Simon Brunswhig.

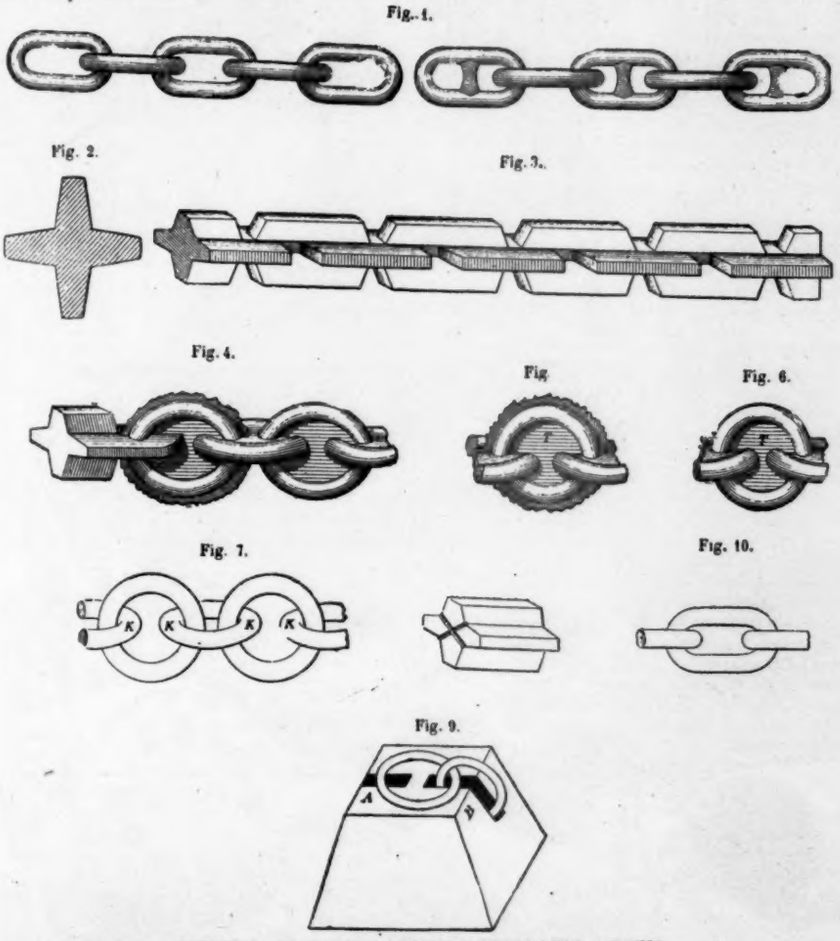
There is hardly any industry where the use of chains is as common, as indispensable, and as important as in the operation of mines, and if iron chains were stronger and more even in their strength their use would be still further extended. In fact, the use of the ordinary iron chain is not without its danger. A bad link or a bad weld may be the cause of a breakage which may have very serious consequences. The weld is, in fact, a permanent danger, for it is impossible to be sure that a weld is perfectly well made even though the outside appearance may not show any defect whatever. The pieces may be perfectly welded together without the center of the link being equally well done, and very frequently a mere sticking is obtained and not a complete weld. So the result is that we are continually hearing of accidents which are caused by the breakage of imperfectly welded chains. For a long time experiments have been conducted in various countries for the purpose of doing away with the weld, and this problem has been solved by M. Oury, who is in charge of the Marine Arsenal at Cherbourg.

The Oruy chain is of exactly the same form as the ordinary iron chain, and is shown by fig. 1. It is manufactured by a series of hammerings on soft steel bars, whose tensile strength is from 57,000 to 64,000 lbs. per square inch of section, with an elongation of from 20 to 25 per cent. These bars are first rolled so as to have a regular cross-section of star-shape, as shown in fig. 2.

The star-shaped bars are first heated to a red heat in special furnaces, and are then run through a nicking machine which stamps out the metal with the alternating nicks on each side,

* Paper read at the Mons meeting of the Society of Engineers of the Provisional Industrial School.

as shown in fig. 3. When this is done the small holes, of which we will speak later, are drilled out cold. Afterward the bars are again returned to the furnaces and run under a series of stamping hammers provided with matrices. Figs. 4, 5, 6 show the appearance of the chain after the successive stampings. The hot metal is thus gradually driven into the matrices, and there is a sort of rolling back to the center of the link; the metal flows around the link and leaves only a thin fin of metal in the center. They then remove this thin fin with a punching machine, and afterward proceed to the trimming down of the inside and outside of each link. At this stage of the operation the star-shaped bar has been formed into a length of rigid links, as shown in fig. 7, which must be detached from each other in order to form a true chain. This operation is accomplished by drilling the small holes, of which we have already spoken, and the drilling is done in the following way: Between each notch, at equal and predetermined distances, small holes are drilled which cross each other in paths in the center of the bar itself, as shown in fig. 8, and



METHOD OF MANUFACTURING WELDLESS CHAINS.

which must meet each other in the exact point of contact of the inside of the links, so that the links which are to be separated from one another are then only held together by four bridges of metal which can be easily cut away. This separation of the links is made by a small drop and thus the chain is formed, although the links are still very imperfect, and though not quite round, are still quite independent of each other.

The trimming off is then renewed, and the chain is again sent into the furnace. In coming from the furnace the chain passes under a new series of drops provided with round matrices, as shown in fig. 9, giving the links a circular form. When a link is in the matrix the two connecting links are perpendicular to the first, and drop into the two openings provided in the matrix. These lateral links protect the two parts of the link which are just above them from the blows of the hammer, whence it becomes necessary to turn the link in its form in order that its whole surface may be subjected to the action of the blows. This is the reason why these matrices are round. The hammering is repeated several times, until the fins produced by the stamping are removed, and a weldless chain of round and very regular links is formed. The chain is again heated and passed into an ovalizing machine which crushes each link between jaws and brings it down to the ordinary form, as shown in fig. 10. If the chain is to be stayed the stemples are put in at this time. The chain is thus completed and is allowed to cool slowly in a pit, from which it is taken to be subjected to the tensile tests.

These chains have given some very remarkable results. Among other tests we may cite one made with a .7-in. chain, where the breaking strain was 53,736 lbs., or 68106.40 lbs. per square inch.—*Revue Industrielle.*

UNITED STATES ARMORED CRUISER "NEW YORK."

THE armored cruiser *New York*, a summary description of which we published in our issue of April, 1891, is now completed and ready for active service, and has been in commission for several months. We give on pages 24 and 25 a full-page illustration of the broadside and bow views of the vessel as she appeared when anchored in the Delaware River. The other illustrations which accompany the article give a very complete idea of the general appearance of the machinery which they delineate. We give in a detailed drawing a front elevation of one battery of the boilers and a side elevation of the same, neglecting the drawings of the general construction of this part of the steam plant, as well as the engines, because they are almost identical in design with those of the *Minneapolis*, which were published in our issue of September, 1893.

The contract for the construction of this vessel was awarded on August 28, 1890, on the plans and specifications drawn up by the Navy Department, with the addition of certain modifications proposed by Messrs. Cramp & Sons, of Philadelphia, Pa., who are the builders. These modifications included merely a rearrangement of the boilers, so that additional longitudinal and transverse bulkheads could be fitted in the engine and boiler space, thereby affording greater protection to the machinery and making the boilers less vulnerable to attacks from rams and torpedoes. The keel was laid on September 30, 1890, and the vessel launched on December 2, 1891. In accordance with the terms of the contract, the vessel is an American-built ship in every sense. The metal is the product of American mills, and all of the work has been done in American shops. The principal dimensions of the hull are as follows:

Length of water line	380 ft. 6½ in.
Molded breadth	64 ft.
Mean draft	23 ft. 3½ in.
Displacement at mean draft	8,150 tons.
Maximum speed	20 knots.
Sustained sea speed	18.5 knots.
Endurance of estimated coal capacity	13,000 miles.

The vessel carries a complement of 475 officers and men. It is built with four complete decks, including the protective deck, and there is a large flying deck or bridge upon which the boats are carried. These boats include a steam as well as a very handsome electric launch, the latter having been but recently put in position. She carries two military masts and has no sail capacity. Each of the military masts has double fighting tops and a lookout. From her freeboard to her upper deck is about 20 ft., and this, together with her size, will enable her to fight her guns and maintain her speed in a sea which would render a smaller ship practically helpless.

Regarding the general construction of the vessel, the vertical

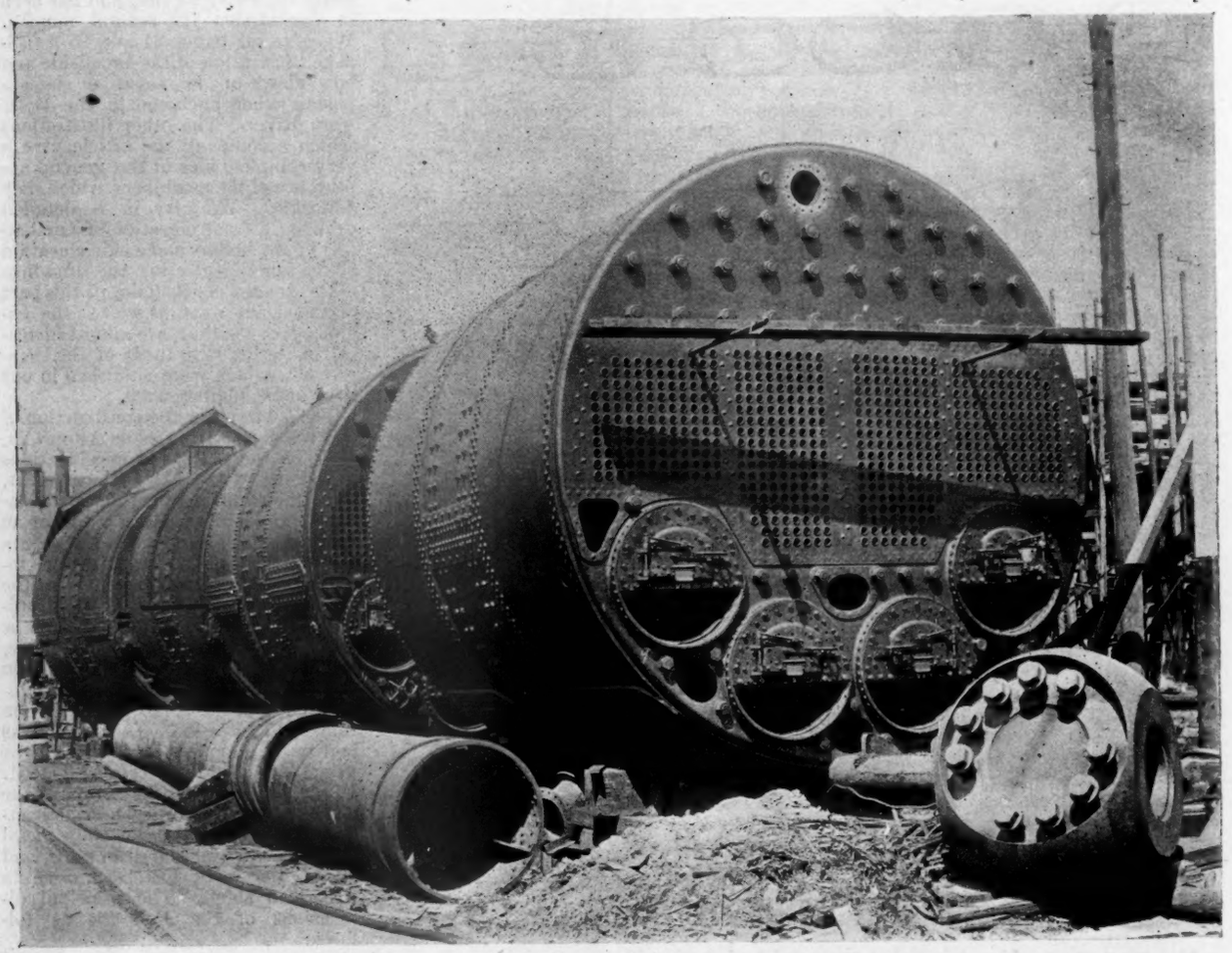
keel is composed of plates weighing 20 lbs. to the sq. ft., held by lower angles of 4½ × 3 in. weighing 13 lbs. to the foot, while the upper angles are 4 × 3 of 10 lbs. each. The stem and stern-posts and shaft struts are made of cast steel, while the rudder frame is a combination of forged and cast steel. The hull has a double bottom, with a space of about 4 ft. between the two. Forward and aft of the double bottom, which is immediately beneath the machinery space and below the protective deck, the frames consist of Z bars measuring 6 × 3½ × 3½ in. and weighing 15 lbs. to the foot, with their lower ends split for the admission of a 10-lb. floor-plate. Z bars are also generally used above the protective deck frames, and are continuous from the protective deck to the upper deck. The intermediate framing is of the same scantling, and is worked in between the protective deck and berth deck behind the side armor. There are three longitudinals on each side with the double bottom composed of 17½ lb. continuous plates. The beams which are used for the upper deck are T deck beams 10 × 5⅛ in., weighing 31½ lbs. to the foot. For the gun deck there is an angle bulb beam 10 × 3½ in., weighing 26 lbs. For the protective deck there is an angle bulb of 10 × 3½ in., weighing 26½ lbs., and the platforms for angle or Z bars 10 in. or 11 in. respectively.

The outer plating amidships weighs 23 lbs. to the sq. ft. from the keel plate to the shear strut. Toward the extremities the outer plating is lightened to 20 lbs. The plating is double between the protective deck and the berth decks in the wake of the thin armor, and the double plates are worked in the wake of the gun ports, where they are exposed to the chafe of the anchors, etc. The protected portion of the ship consists of a complete protective deck, which at the sides is 4 ft. 9 in. below the water-line, 1 ft. below the water amidships, and 1 ft. above the water when the vessel is at the mean draft of 23 ft. 3½ in.; it is completely covered with two courses of plate having a thickness of 3 in. amidships and 2½ in. fore and aft. The slopes amidship are covered with an additional thickness of 3 in., making their total thickness 6 in. Then there is a partial belt of armor. In the wake of the machinery space the belt of thin armor is worked between the protective and berth decks, and the total thicknesses of metal throughout this space is 5 in. The cofferdam is 3 ft. 6 in. deep, and is worked in between the protective and berth decks, extending completely around the vessel, and this is filled with an improved water-excluding material.

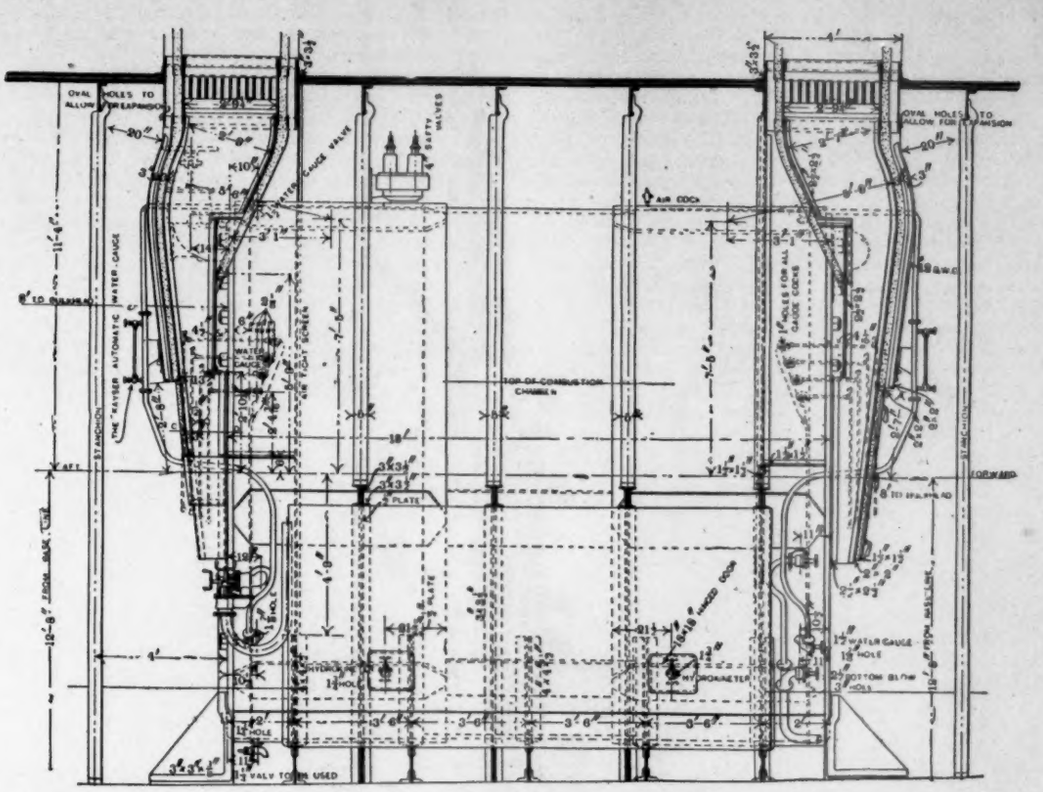
A large proportion of the coal supply is stowed on the armor deck, forming an additional safeguard against the effects of damage near the water-line.

The battery of the vessel consists of six 8-in. breech-loading rifles, twelve 4-in. rapid-firing guns, eight 6-pdr. rapid-firing guns, and four 1-pdr. rapid-firing guns, four Gatling guns, and six torpedo tubes. Two of the 8-in. guns are mounted in a barbette forward on the upper deck, and two more are in a similar barbette aft, while the remaining two are carried in broadsides amidships on the upper deck. The barbettes in which these guns are placed are 10 in. thick, while the revolving conical shields on the guns themselves are 7 in. The sloping armor between the upper and gun decks beneath the barbette is 5 in. thick, while the ammunition tubes below are also 5 in. The 8-in. broadside guns are protected by partial barbette 2 in. thick and shields on the guns. The 4-in. rapid-firing guns are mounted on the gun deck in armored sponsons which are 4 in. thick and which have shields on the guns closely covering the ports. Their protection is further insured by 1 in. splinter bulkheads. The 6-pdr. guns are protected by 2-in. armor or its equivalent. There is one torpedo tube in the bow, one in the stern, and two training on each broadside, each being above the water-line by about 4 ft. The 8-in. guns are 25 ft. and the 4-in. guns 16½ ft. above water.

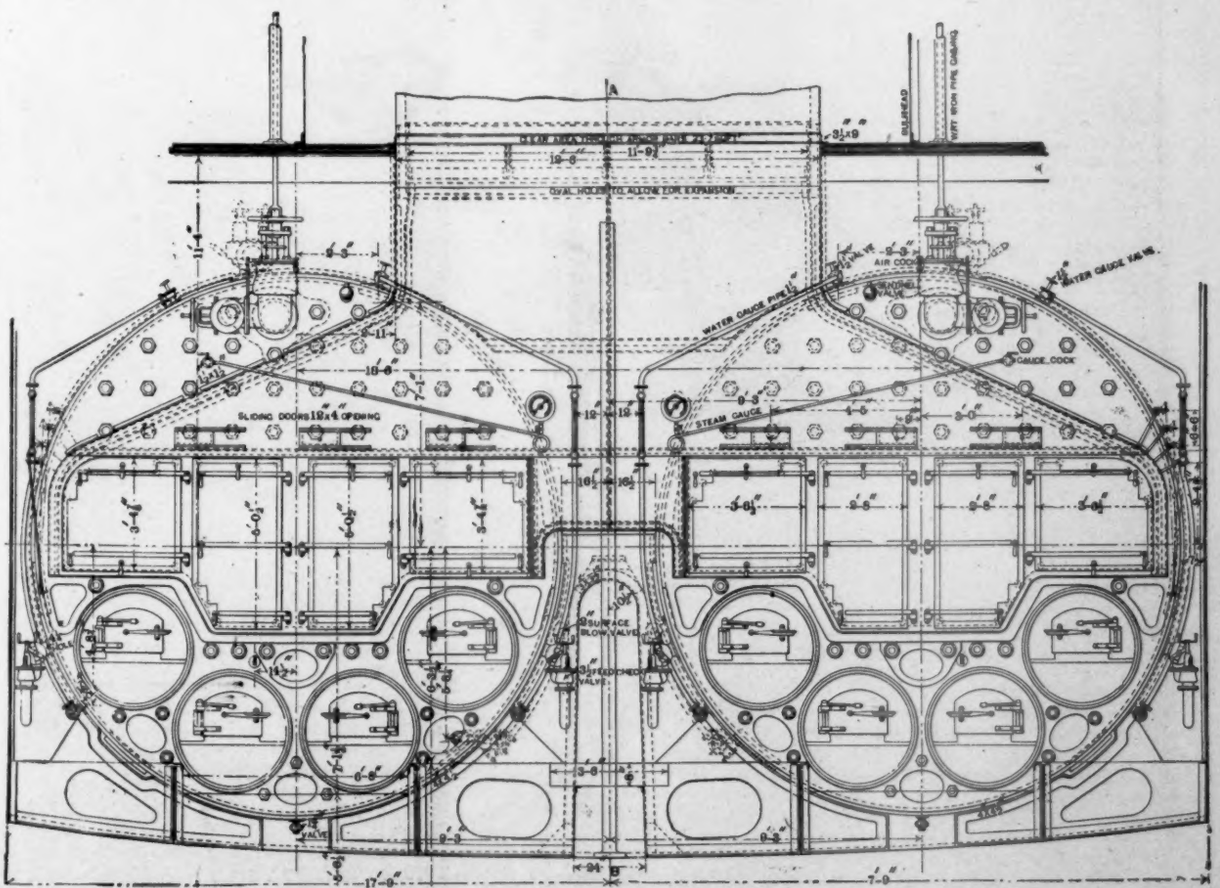
The vessel has a complete electric lighting outfit, which is arranged in accordance with the most recent practices of the service. There are three search-lights on the vessel, one forward and one on either end of the flying bridge amidships. The military masts are of steel with internal arrangements for the ascension of men and the whipping up of ammunition for



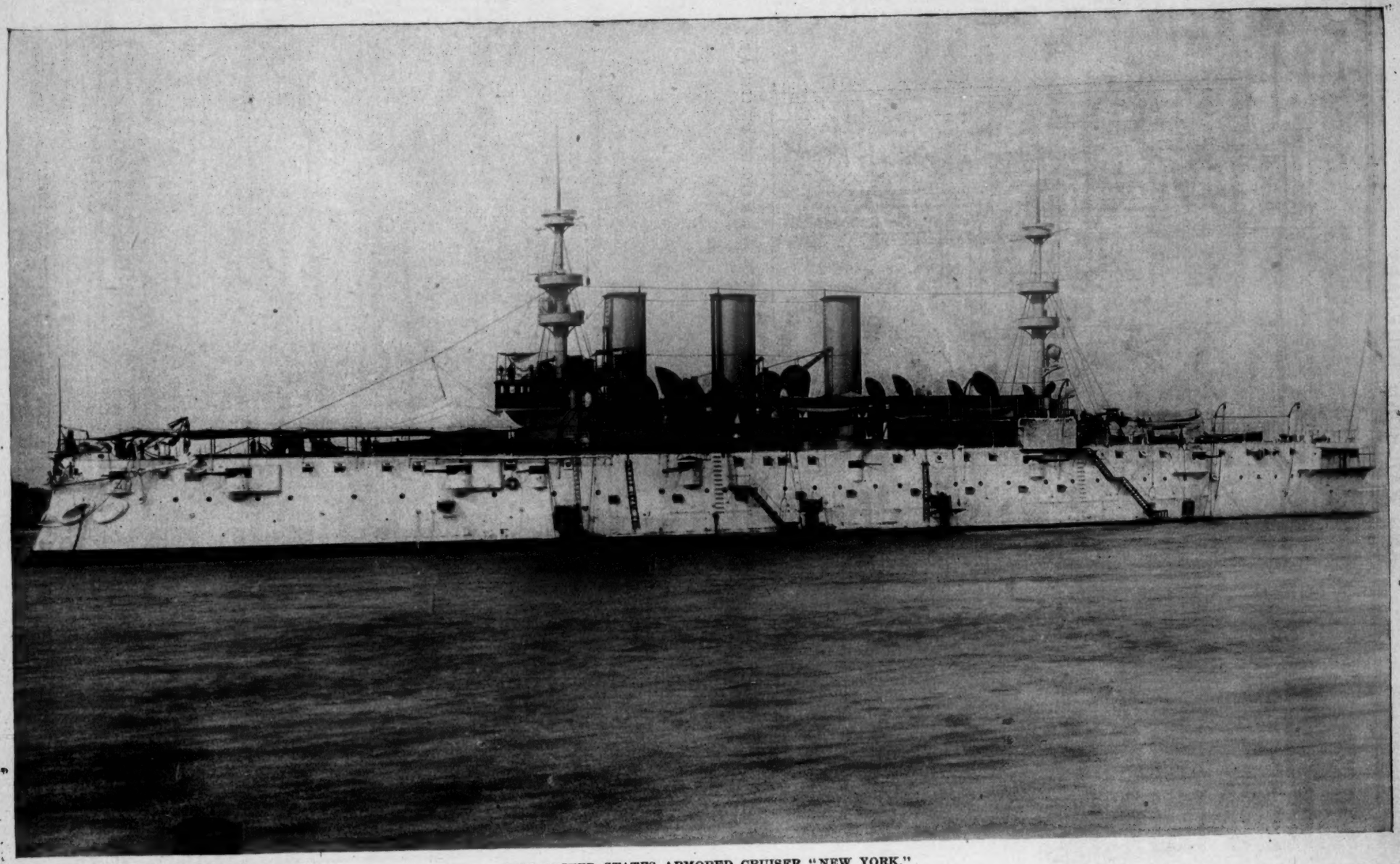
BOILERS OF THE UNITED STATES ARMORED CRUISER "NEW YORK."



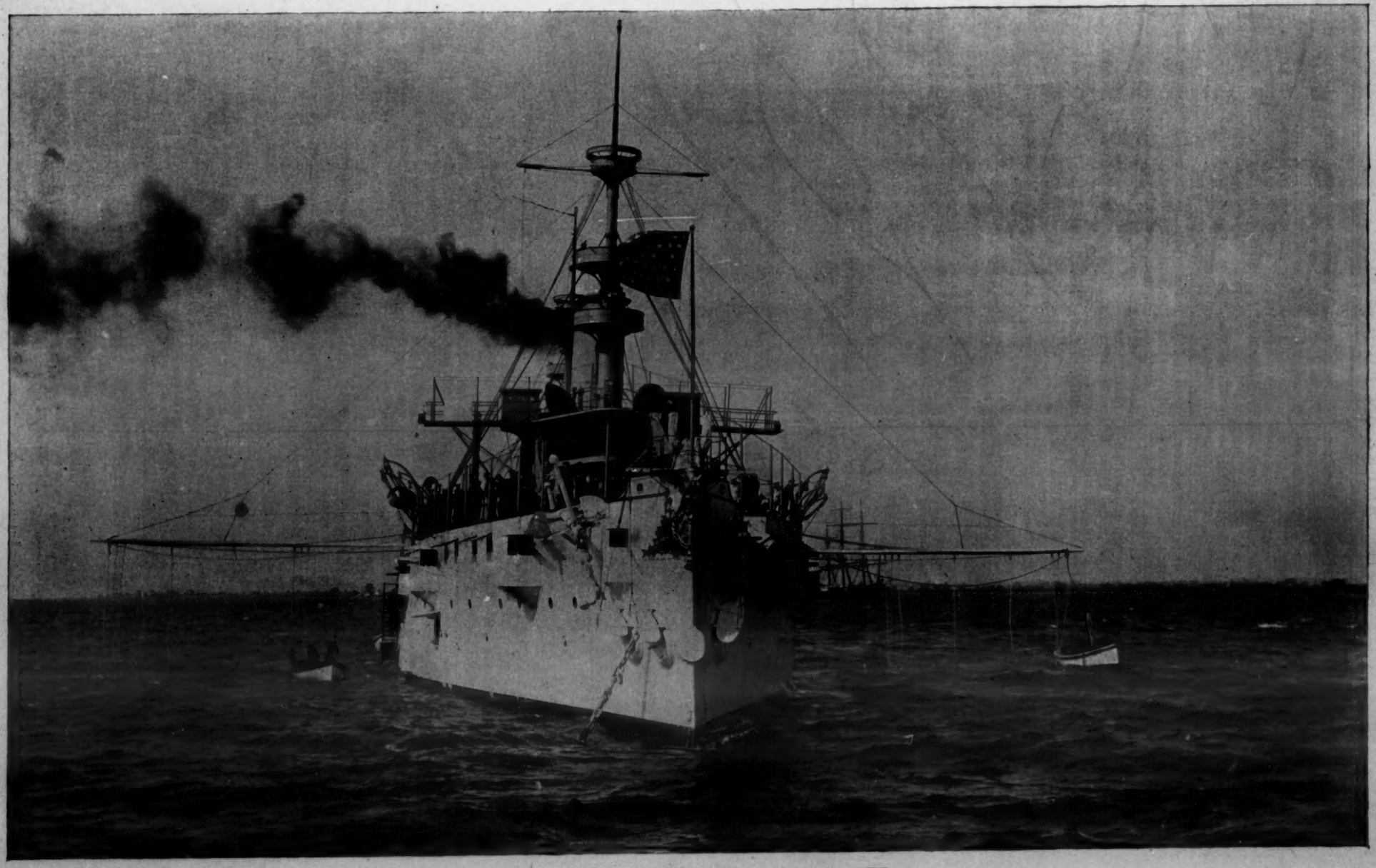
SIDE ELEVATION OF BOILERS OF THE UNITED STATES CRUISER "NEW YORK" FROM SECTION ON LINE A B.



FRONT ELEVATION OF BOILERS OF THE UNITED STATES CRUISER "NEW YORK."



THE UNITED STATES ARMORED CRUISER "NEW YORK."



THE UNITED STATES CRUISER "NEW YORK."—BOW VIEW.

the rapid-fire guns which are mounted in them. Davidson steam steering gear is used, but it is also possible to disconnect this and steer by hand from a bridge just abaft the mainmast should any accident happen to the steam apparatus. Forward there are three wheels for handling the vessel, one on the bridge, which is unprotected, and is used for entering the harbors and handling the vessel in fair weather. Beneath this there is a wheel and chart-house, which is protected from the weather, and has the general appearance of the wheel-house of an ordinary river steamer. This is intended for use in bad weather at sea. Beneath the chart-house is the conning tower, where a wheel is located, which is, of course, only intended for use in time of battle. All of this apparatus is placed just forward of the mainmast.

The most recent improvements in engine and rudder indicators are duplicated in each of these three positions. There is an indicator which shows the speed and direction of each engine. Opposite this there is another engine-room indicator which shows the rate and speed of the last order which had been issued from the bridge, and the two should, of course, correspond, except at the very instant of the issuance of the fresh order. There is a telephone communication with all of the vital parts of the ship, and also telephone communication with the switch-board, which is practically the central office of the telephone system, at which connection can be made to other portions of the vessel.

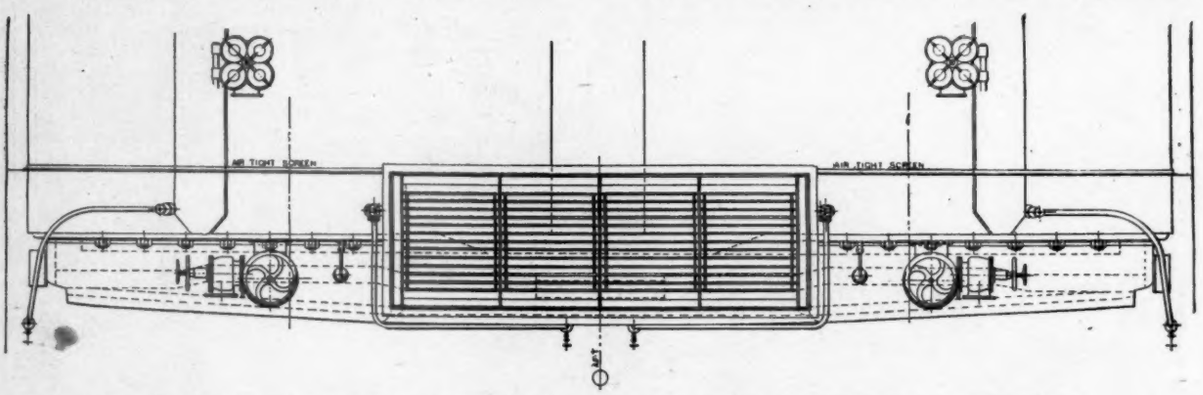
The chart-room is a large, airy apartment, where all the charts of the vessel are kept, and it is handsomely finished in mahogany. The crew's quarters are remarkably clean and airy. The hammocks are stowed on the upper deck during the day and slung from the overhead beams of the berth deck at night. There are ample arrangements for artificial ventilation throughout the whole vessel, and in the living quarters there is a natural ventilation in addition. Great care has also been taken that the pumping and drainage arrangements should be thorough and effective. The vessel is fitted as a flagship, and in addition to the quarters of the admiral and captain there are state-rooms for 20 ward-room officers, 12 junior and two warrant-officers. The interior fittings of these apartments are in oak, with furniture upholstered in handsome leather. Scattered about the ship in various points are the flags and other things which have been presented to the officers and the ship by the citizens and various societies of the city of New York.

In the construction of the vessel there is a longitudinal bulkhead running between the engines and the starboard and port boilers, but forward and aft of this there are no longitudinal bulkheads, but simply transverse, which are closed by the usual type of water-tight doors.

The machinery of the vessel consists of four vertical triple-expansion engines. It was thought advisable to divide up the power of the vessel in this way in order that for ordinary cruising one-half of the available power may be used for economical workings. This is in accordance with the policy which has been laid down by the Navy Department, and which is brought out very prominently by Mr. Melville in his paper on The Machinery of the New Vessels of the United States Navy, published on another page of this issue. Each of these engines is of about 4,000 indicated H.P., and they drive twin screws, two being placed upon each shaft. By means of an easily worked coupling the forward engines are readily disconnected, so that the after set can be used alone; and as these can be worked at nearly the power for which they were designed and at full boiler pressure, the economy will not be reduced as in the case where a triple-expansion engine is worked at a low power and under reduced pressure. There is, of course, some disadvantage in using engines designed in this way, as it results in an increase of weight and a space occupied by the machinery as well as in a greater number of parts that are liable to become deranged; but, in the opinion of the chiefs of the department, it is considered that these are outweighed by the advantages of economical workings, which we have already mentioned. The engines are direct-acting and have cylinders of 32, 46, and 70 in. in diameter, with a common stroke of 42 in., giving a collective indicated H.P. of 16,000 when the engines are making 125 revolutions per minute, with a resultant piston speed of 903 ft.

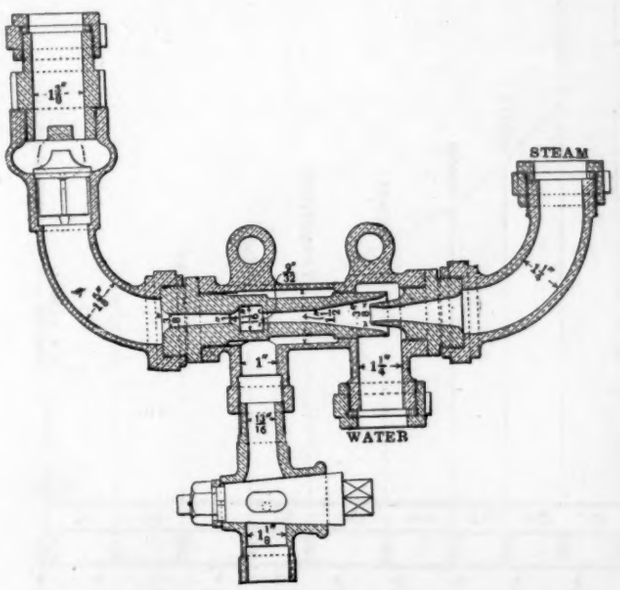
The general appearance of the engines is almost identically that of the engines used on the *Minneapolis*, which we illustrated in our issue of September, 1893. The principal differences between the two lie in the fact that whereas the low-pressure cylinder on the *Minneapolis*' engine was furnished with four valves, the engines of the *New York* have but two; and, also, that while the front of the *Minneapolis*' engines was held by round vertical columns, there is an inverted Y frame on each side of the *New York's*. The diameters of the cylinders are also different, but, with the exceptions which we have already noted, the general appearance of the engines is practically the same.

Regarding the details of the dimensions, piston-valves are exclusively used; they have a diameter of 16 in. for the high-pressure cylinder, with a mean diameter for the low-pressure cylinder of 29½ in. All the valves are driven by double-bar Stephenson links. The intermediate and low-pressure cylinders are jacketed on the sides and bottoms, while the high-pressure cylinders are fitted with a lining or wearing cylinder of hard cast iron. All of the pistons are of cast steel. As we have already said, the cylinders are carried by inverted Y frames made of cast steel, to which the cast-iron guides are bolted. The bed-plates are of cast steel of an I section, and are securely bolted to the engines' keelsons, which are built in the ship. The piston connection and other working parts of the engines are of mild steel, as well as the crank-shaft, which is forged in three sections for each engine. The forward shafts are 13½ in. in diameter, with 6 in. axial holes, while the after shafts are 17 in. in diameter with 7½-in. axial holes, so that the shafts are not interchangeable There is a cast-steel coupling between each forward and after engine crank shaft, which occupies but little room and by means of which the engines can be quickly coupled or uncoupled. Each engine with its auxiliaries, such as pumps and condensers, is located in a separate water-tight compartment, and is entirely independent of the other. The main condensers are made of a cast composition and rolled brass, and are bolted and riveted together. They are made of three sections 5 ft. 9 in. in diameter, with a total length of 9 ft. inside tube sheets. Each condenser contains 3,775 seamless drawn tubes No. 20 B. W. G. thick, tinned on both sides, which gives 5,559 sq. ft. of cooling surface. Each tube is separately packed at each end, and is free to expand independently of the others. The condensing water is supplied by a separate centrifugal circulating pump for each engine which has a capacity of 8,000 galls. per minute, which may be discharged either through the condenser or directly overboard by way of the outboard delivery, and may be taken from the sea or bilge at will. The pumps are driven by engines attached directly to the main shafts. The air-pumps are vertical single-acting lifting pumps, each with two pistons of 19 in. in diameter and 18 in. stroke. They are driven by vertical engines with cylinders 7½ in. in diameter and a stroke the same as that of the pump placed directly over



HORIZONTAL SECTION THROUGH BREECHING AND UPTAKE, UNITED STATES CRUISER "NEW YORK."

it. The air-pump engines are simple, but the steam from them may be exhausted into either the intermediate or low-pressure receiver as well as into the condenser, and so be worked with a full measure of economy. Steam is supplied by six double-ended steam boilers placed below the protective deck and two auxiliary boilers placed above it. The main boilers are 15 ft. 9 in. outside diameter and 18 ft. long. They are double-ended, with four fire-boxes at each end, placed in corrugated furnaces of 3 ft. 7 in. outside diameter, and composed of metal $\frac{17}{32}$ in. thick, each being 7 ft. $1\frac{1}{2}$ in. long. The tube sheets are 6 ft. 6 in. apart. These boilers are almost identical in design with those which were fully illustrated in September, 1893, in connection with the cruiser *Minneapolis*, except at the top and ends; the end sheet of these boilers is brought up square and flanged over with a very short radius instead of being given the broad, long sweep and curve that appears in the boilers of the *Minneapolis*. These boilers are located on either side of the longitudinal bulkhead, and are placed in separate water-tight compartments in batteries of two, so that each battery is entirely independent of the others. Our illustrations show the general appearance of the arrangements of the front of this battery. There is a passage-way from one fire-room to the other between the boilers and through the gangway, which is clearly shown upon the engravings. This gangway is 21 in. wide at the top and 24 in. at the bottom and 6 ft. high above the floor-line. The side elevation of the arrangement of the boilers shows the connections which are made with the bridge and the run to the stack. It will be seen that the bulkhead comes very close to the front of the boiler, and there is but little space in the fire-room for coal heaps, so that the supply must come in continually. The figuring and lettering on the engravings give such complete details of the construction and the arrangements of the boiler that further detail regarding it is unnecessary. For the type and arrangement we would refer our readers to the engravings published of the boilers of the *Minneapolis* in September, 1893.



INJECTOR, GRAND TRUNK RAILWAY.

The heating surface of the main boilers is 31,190 sq. ft., and the grate area 988 sq. ft. The auxiliary boilers above the protective deck have each two steel corrugated furnaces 2 ft. 9 in. internal diameter, with a total heating surface of 1,937 sq. ft. and a grate area of 64 sq. ft. The main boilers have 572 $2\frac{1}{4}$ in. steel tubes, but in the auxiliary boilers the tubes are $2\frac{1}{4}$ in. in diameter. The main boiler shells are butt riveted, with inside and outside welts triple riveted. The thickness of the shell is $1\frac{31}{64}$ in., and the working pressure is 160 lbs. A mild forced draft is used on the closed fire-room system. The screws are three-bladed propellers with adjustable blades, and are made of manganese bronze. There is also a complete hydraulic plant for supplying and working the battery and operating the turrets.

The final trial of the *New York* was ended on December 14. This was an endurance trial to ascertain the action of the ship in service conditions. The coupling on the two forward engines was accomplished in a little less than 20 minutes after the order was given. The result of the turning trials was also highly satisfactory in all respects. The cruiser showed her ability to turn in a circle three times her own length, and with one propeller backing and the other going ahead the vessel was swung around a circle which was only 275 yds. in diameter. The following table shows the approximate result of the turning trials:

Evolution.	Time of Putting Helm Over, Seconds.			Number of Revolutions on Straight Course.		Number of Revolutions on Curved Course.		Estimated Diameter of Circle in Yards.	Time to Complete Circle.
		Starboard Engine.	Port Engine.	Starboard Engine.	Port Engine.	Starboard Engine.	Port Engine.		M.S.
Helm hard a-starboard, both screws ahead full speed	35	82	80	79.5	70.0	400	5	25	
Helm hard a-port, both screws ahead full speed	34	..	..	72.8	73.0	350	6	01	
Helm hard a-starboard, starboard screw ahead, port screw astern half speed	19	..	..	87.5	68.3	375	5	51	
Helm hard a-port, port screw ahead, starboard screw astern half speed	20	..	..	70.0	87.5	350	5	58	
Helm hard a-port, port screw ahead, starboard screw stopped	16	..	..	....	72.3	350	6	48	
Helm hard a-starboard, starboard screw ahead, port screw astern	14	..		73.5	74.8	275	7	29	

From full speed ahead the time from signal "Stop!" to entire loss of headway was 9.07. The estimated distance traversed was 750 yds. From full speed ahead it was found that the vessel could be brought to a stand-still by reversing her engines in 1.46, and before she had run her own length. With both propellers making 102 revolutions per minute the speed of the vessel was 15.93 knots per hour. Owing to the great foulness of her bottom, no higher speed could be gotten out of her. Forced draft was not used.

After the turning trials the firing tests were had. Two charges were fired from each of the main-battery guns, and five from each piece of the secondary battery. Common shell was used with service charges.

The vessel has thus passed all the requirements of the Navy Department, and been shown to be one of the finest vessels of the new Navy.

GRAND TRUNK RAILWAY INJECTOR.

We illustrate an injector which is made by the Grand Trunk Railway for use on their locomotives. It is perhaps not widely known that the Grand Trunk Railway manufacture nearly all of the apparatus and fittings which they use on their engines and cars. Inasmuch as there is a high protective duty in Canada, and as the manufactures of Canada are not extensive enough to supply all of the requirements of a railway, it has been found by the Grand Trunk Railway that it is cheaper to manufacture their own goods than to import from the United States and pay the custom house duty. The injector which we illustrate will be seen to be very simple in construction and readily accessible for repairs. The general dimensions are given on the engraving, and from an examination of the parts it will be seen that they are very substantial and require the minimum amount of machine work in their construction. The steam and delivery pipes, as well as the suction pipe for water, are large, and the combining tube has an ample delivery into the delivery pipe, where there is a check-valve through which the water passes before reaching the long run to the boiler check.

Protecting Metals from Rust.—According to the *Polytechnisches Notizblatt*, articles of steel and iron can be protected against rust by coating them electrolytically with peroxide of lead. A satisfactory coating can, it is said, be obtained in 20 minutes, and is perfectly proof against atmospheric influences. As the whole operation is conducted at ordinary temperature, the temper of steel articles is unaffected by it.

THE GOVERNMENT NEW LOCATION FOR THE RAILROAD ACROSS THE MAIN CAUCASUS RANGE.

By A. Zdziarski, C.E.

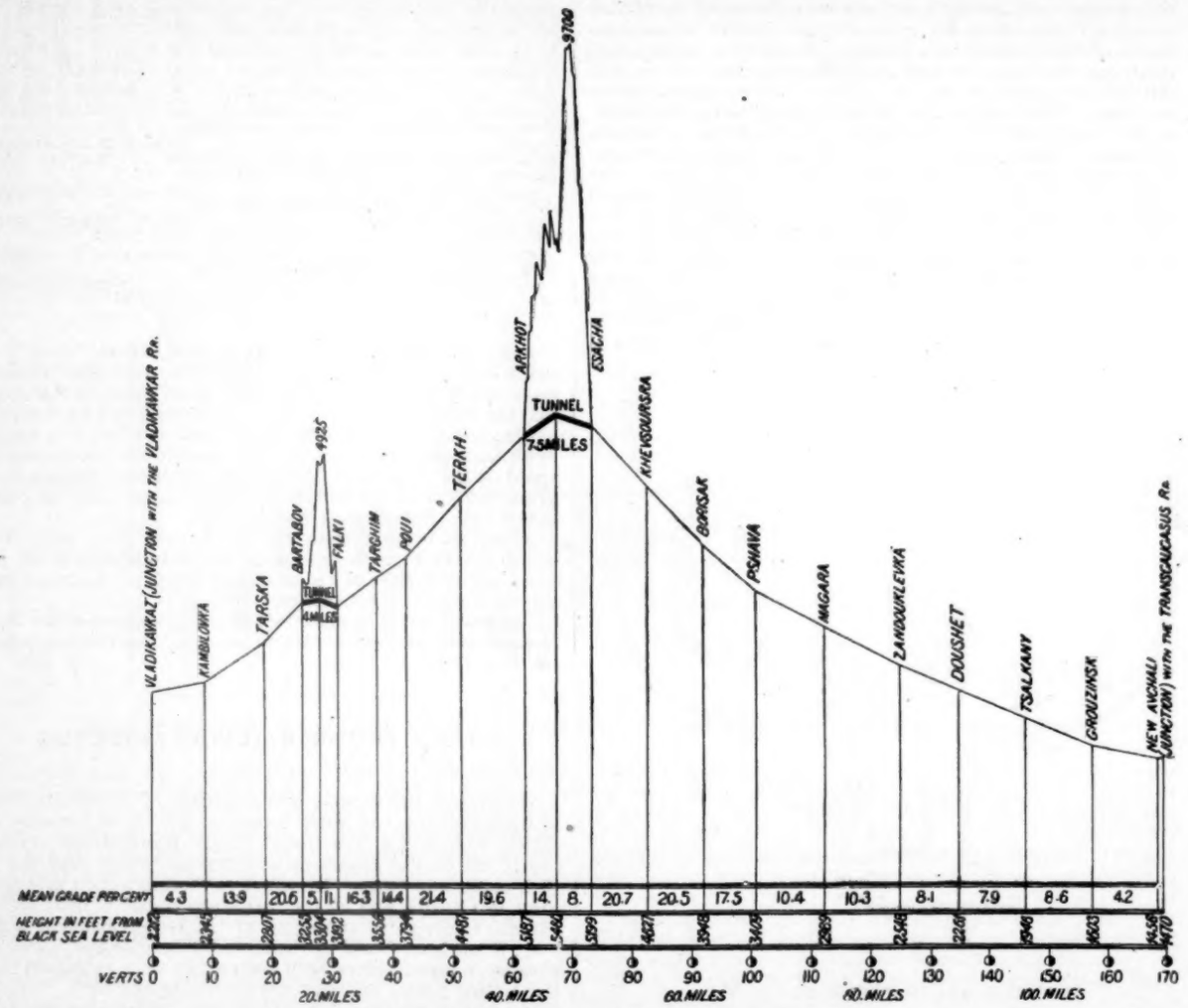
(*Continued from page 587, Volume LXVII.*)

To describe the main features of the located line we must divide it in two parts, southern and northern, each of which consists of two sections, the level section and the mountain section.

The southern level section, 44 miles long, with ruling grade 1.5 per cent., starts from the station New Avchaly, of the Transcaucasian Railroad, and follows the valleys of Koura (3 miles), White Aragva (23 miles), and Pshava Aragva (18 miles). The valleys are so large and their slope so small that the line is located on their bottom, except when small headlands or ridges were to be crossed, or when narrows were met. The neighboring mountains consist of argillous slate (schist). Other stones, as limestone and sandstone, are found only in narrows, the former in Zinvan narrow, and the latter in Magar narrow.

The southern mountain section, 18 miles long, with ruling grade 2.8 per cent., follows the upper end of the valley of Pshava Aragva, and then the narrow or cañon of Khevsour Aragva (14 miles), and ends at the southern portal of the main tunnel. The valleys of these rivers become still narrower, and the slope of their bottom still greater, but up to the station Borisac the line can yet be often located on the bottom of these valleys. Near that point a tunnel 3,129 ft. long must be designed, for the slope of the bottom of the cañon is greater than the maximum grade of line, and the location must apply to an artificial lengthening of the line, which, thanks to the narrowness of the cañon, could be made only by means of spiral tunnels with a radius of 700 ft. This lengthening of the line reached 17,843 ft. The mountains consist of argillous slate and partly of crystalline slates.

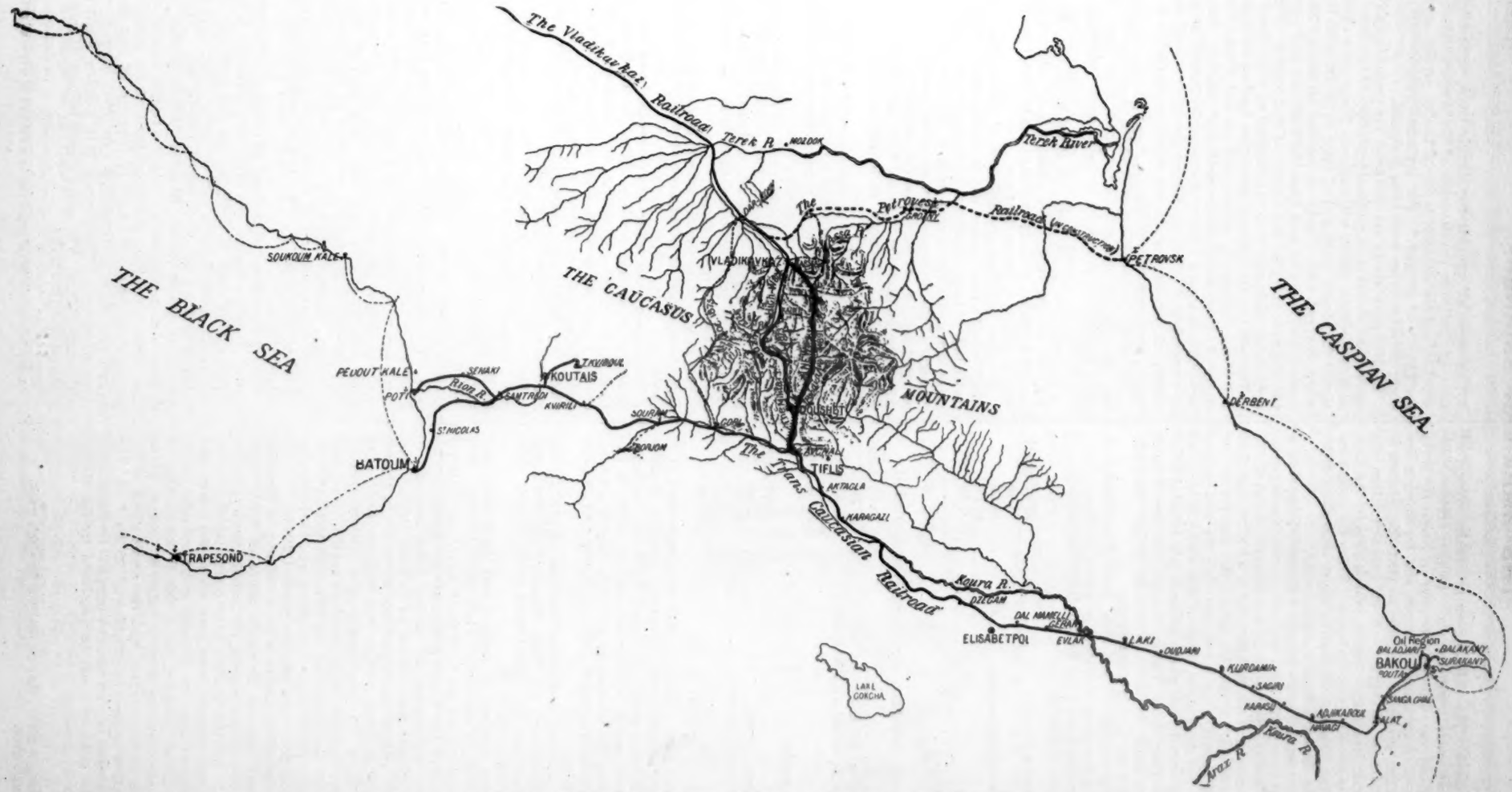
The main Arkhot tunnel has the length of 7.58 miles. It consists of a middle level 1,400 ft. long and 5,475.05 ft. high, and two grades to both portals—the southern grade 0.8 per cent. and northern 1.4 per cent. The absolute height of the summit on sea level is 9,699.7 ft. The range consists here of paleozoic argillous slate (schist). The northern slope contains a layer of crystalline diabase. The southern slope is covered by alluvium, which allows agriculture to the height of 6,000 ft., and from 6,000–8,000 ft. produces Alpine prairies. On the northern slope prairies are found from 6,000–7,000 ft., and under 6,000 ft. the mountains are completely covered by coniferic forest. On the summit the time free from snow is from June 20 to September 1; near the portals from May 1 to October 1. In deep and narrow cañons on the height of 5,000 ft. the snow remains all the year round.



PROFILE MAIN LINE OF TRANSCAUCASIAN RAILROAD.

The main tunnel is designed for double track; it will require 1,272,000 cub. yards of cutting and 352,600 cub. yards of masonry. The motive power for the air compressors, ventilators, etc.—about 1,000 H.P.—can be got from mountain rivers, which on the southern side give a minimum discharge of 100 cub. ft. per second, and on the northern side 170 cub. ft. per second. This discharge, combined with the slope of these rivers, 5 to 7 per cent., can furnish the required motive power on each side.

The northern mountain section, from the northern portal to the Kambilavka station, is 35 miles long, and its maximum grade is 2.8 per cent. From the northern portal of the main tunnel the line descends the cañon of the river Assa, the slope of which, on its first 7 miles, considerably surpasses the maximum grade of the line. Therefore the same must be lengthened by 22,603 ft.; and as the cañon is very narrow and tortuous there, many deep cuttings, tunnels and retaining walls



MAP OF MAIN LINE OF TRANSCAUCASIAN RAILROAD AND CONNECTIONS.

have been designed. The neighboring mountains consist of more strong paleozoic argillous slate (schist), crossed by many crystalline layers. From the estuary of Nelka River (in Assa) the valley of Assa becomes larger, and its slope is less than the maximum grade of the line, so that the location is laid on the bottom of the valley. Near Targim station the region of Touraic limestones begins, and is crossed by Assa River, which has cut a narrow for itself. From the following station (Falki) the line was studied in many directions, from which that going through Tarska was selected.

This line begins with Tarska tunnel, 4.05 miles long, with a middle level and two grades—1.1 per cent. to the eastern portal (3,192 ft. high) and 0.5 per cent. to the western portal (3,255 ft. high). The height of the middle level is 3,306 ft., and that of the summit 4,925 ft. From this tunnel the line enters the narrow valley of Kambilavka River, and then the wide valley of Tara River; but the general slope of this valley is so great that till Tarska station, the grade of mountain location must be allowed. Starting from Tarska station, the line follows the Kambilavka cañon (narrow), where the grades are 2 per cent., and reaches the Kambilavka station.

The remaining portion of the line, from Kambilavka to Vladikavkar, 6 miles long, is located as a level section.

Resuming the above data, we get the following figures:

The total length of the line—

The southern level section	45.17	miles.
" northern " "	6.15	"
" southern mountain section	18.33	"
" northern " "	35.00	"
" main tunnel	7.58	"
	112.23	"

According to the curvature, this length is so divided:

Straights	70.10	miles.
Curves with radius of 1,400 ft. or more	15.90	"
Sharp curves, with radius of 700–1,400 ft.	26.23	"
	112.23	"

According to grades:

Levels	14.93	miles.
Grades 1.5 per cent. or less	59.90	"
Grades from 1.5 to 2.8 per cent.	37.40	"
	112.23	"

The Design and Cost.—The road-bed for single track (5 ft. wide) is designed 18.2 ft. wide. The total quantity of earth-work is 12,833,000 cub. yards, or about 115,000 cub. yards per mile. The greater part of earth-work.—63 per cent—is embankments. From the balance—37 per cent.—the 25 per cent. are cuttings in ordinary ground, and only 12 per cent. in stone of various hardness.

The retaining walls are designed of the type adopted for the St. Gothard Railroad and the Oufa Zlatooust Railroad, and with the provision that the second track could be laid. The total length of them is 32,277 ft.

The culverts are designed of stone 3½ and 10½ ft. wide, and are small, 2½ ft. wide, of cast iron. Their number is 148. The abutments of small bridges up to 28 ft. in height are designed with buttress walls. The higher abutments are designed with inside wells, the application of arches being insecure in mountain country, with foundations on inclined strata. The number of small bridges and aqueducts up to 105 ft. span is 205; the number of great bridges and viaducts (with span more than 105 ft.) is 32. The most notable constructions of that kind are four viaducts on the northern section, with total length of 1,666 ft.; one viaduct on the mountain section 210 ft. long, and a bridge 105 ft. span, also there, and four viaducts on the southern section, with total length of 1,218 ft.

The chief feature of the design is the abundance of tunnels; there are 42 small tunnels for single track, of total length 55,247 ft., and two great tunnels, for double track, of total length 61,086 ft. All the tunnels have been divided in three classes: 1. The main tunnels, very long, where the line crosses the dividing ranges; they are straight and for double track. 2. The spiral tunnels, intended for artificial lengthening of the line in the case when the slope of valley is greater, as the maximum grade of the railroad and the small width of the valley does not allow an open lengthening of the line.* 3. The ordinary small tunnels in such places where the line meets any lateral mountain head, or must be protected by the tunnel against the snow avalanches.†

* The radius of curve is 700 ft.; they are designed for single track.
† Designed for single track.

The types of tunnels for double track were adopted the same as applied in construction of the Souram tunnel. There are designed six different types of tunnel profile, according to the quality of ground.* For the small (single-track) tunnels, eight different types have been designed.

Special snow-sheds are designed for protecting the railroad against snow storms in mountain portions of the line. In level section the snow shield will suffice. These snow-sheds are designed for single track and of light type, from timber framework, covered with planks in manner of shutter blinds (persienne), which can be shut from the wind side and opened from the opposite side for the escape of the smoke. The cost of such sheds with iron roofs is estimated at about $20 a foot.

The solid snow-sheds as protection against avalanches were not found sufficiently secure, and are not allowed in the design. As more secure means against avalanches, three devices have been designed: one to go under the path of an avalanche in a tunnel, one to lay the line on the other side of the valley, where the avalanches do not occur, or to pass over the avalanche by means of a bridge.

The width of ballast-bed will be 10½ ft., and its thickness 17 in.; the ties of pine or oak 8 ft. long, 2,360 for a mile. In great tunnels the ties to be metallic, each weighing 108 English pounds.

The rails to be of steel, 72 Russian pounds (66 English pounds) to the yard. The joints will be angle splices, with two underplates fixed by means of four bolts and spikes, and will be placed between the ties.

The line buildings are designed of three types: large and small watchmen's houses and section-houses. Eighty-seven small and 14 large watchmen's houses are so distributed that there is a watchman at each mile of the line and at each level crossing of the railroad. For each roadmaster, with his gang of trackmen, a section-house (18 in number) will be built. All the buildings to be of stone, with sheet-iron roofs. There will be 64 road crossings, protected (as above said) by gates and watchmen.

The station buildings, in consequence of the sparse population of the country, need not be large; they are designed of stone, with iron roof, 10 in number, two of them being of the third class and eight of fourth class.

The engine-houses are designed of the size necessary for three trains daily in each direction. They are five, and have altogether 21 stalls. They are designed of stone, with iron roofs covered with galvanized sheet iron. Each engine-house contains a small repair shop.

The buildings for the officers and employés of the operating staff are designed to be of stone or wood, with iron or timber roofs.

The stations and water supply are designed with the supposition that the trains will be driven on the first 53.16 miles, from New Avchaly to Pshava (level section), by one engine; on the remaining portion, from Pshava to Vladikavkaz, the same trains will be driven by two engines. According to them, two large engine-houses (in Vladikavkaz and Pshava) and two small ones must be built.

The water supply is designed for the requirements of 14 trains daily in each direction, it being assumed that each train wants from 11 to 13 cub. ft. per mile, and on the mountain section double that quantity. According to these data, the quantity of daily water supply was computed, varying from 8,000 to 18,000 cub. ft. The providing of stations with water is in a very favorable condition on that line. As the railroad follows the valleys of considerable mountain rivers, the discharges of which are above the necessary water supply of stations, therefore this water supply is quite guaranteed. Besides, for the greater part, the topography of the country allows water to be supplied by means of gravity and without pumping. Steam engines will very seldom be required. The standard water-tanks are of boiler plates, having a capacity of 1,370 and 2,740 cub. ft. Two hydraulic cranes will be placed at each station.

For the equipment of stations, 84 switches, three large turntables, 21 switch-houses, and other accessories are to be used.

The rolling stock is designed for one passenger train and two freight trains daily in each direction. The train will consist of 34 military cars or 24 loaded freight cars. The average speed in mountain section, 10 miles; in level section, 13½ miles an hour. According to this data, 344 freight cars are required. The passenger rolling stock, designed of the American type (on eight wheels), will consist of four cars of first-class, eight second-class cars, 15 third-class cars, four baggage cars, and three prison cars. The engines, 56 in number, eight-wheeled, will weigh 48 tons. The mean annual mileage of such engines is placed at 12,000 miles.

* A special description of types can be a subject of a special article.

The estimates of the route give the following cost of the line (112.23 miles):

	Cost in roubles.
1. Expropriation, lands, etc.	451,290
2. Earthwork	7,346,135
3. Bridges	6,164,055
4. Tunnels	31,815,320
5. Track	3,183,180
6. Road accessories	149,572
7. Telegraph line	113,744
8. Road building and gates	336,020
9. Station buildings	591,400
10. Water supply	175,000
11. Station accessories	164,550
12. Rolling stock	3,418,106
13. Roads and temporary roads	1,579,440
14. General expenses	3,878,332
Total	59,366,145

The principal part of cost belongs to the construction of tunnels—viz., 54 per cent. of the total cost. The cost of construction of the main Arkhot tunnel was estimated at 414 roubles ($207) per foot; the cost of second great tunnel (Tarska) was estimated at 281 roubles ($140) per foot.

In order to compare this estimate with those of St. Gothard's and Arlberg Railroad, we give the following table:

	Arkhot Proposed Railroad.	St. Gothard's Railroad.	Arlberg Railroad.
The whole length of the line, miles	112.23	68.93	40.33
The length of main tunnel, miles	7.58	9.31	6.42
The length of remaining tunnels, miles	14.58	11.58	0.27
The length of open line, miles	90.07	48.04	33.64
The maximum height of the open line above sea level, feet	5,302.5	3,757	4,272
Cost of main tunnel in dollars:			
Total	$8,240,792	$10,390,000	$7,671,000
Per mile	1,087,366	1,015,565	1,282,974
Cost of the remaining part of railroad with other tunnels in dollars:			
Total	$21,442,230	$15,614,000	$5,826,800
Per mile	204,862	264,555	176,530
Cost of the whole railroad in dollars:			
Total	$29,683,073	$26,163,000	$14,222,000
Per mile	264,444	379,532	352,680

From this table it is obvious that the estimate of the proposed railroad does not exceed the costs of the great European Alpine railroads; however, in virtue of the protectionist system in Russia, a great many articles—viz., rails, iron bridges, rolling stock, working machines, cement, etc.—are considerably dearer than in Western Europe.

SPECIAL TOOLS OF THE PHILADELPHIA & READING RAILROAD.

HORIZONTAL DRILLING ATTACHMENT.

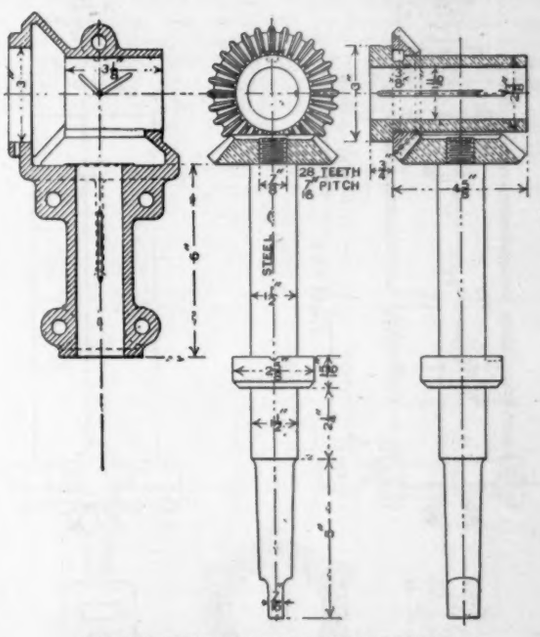
THE days when the drilling of bolt holes in pedestals and other similar parts of a locomotive, which were difficult of access in the ordinary drilling press with a hand-ratchet, are undoubtedly of the past. We illustrated in our issue of June, 1893, a drilling device attached to a flexible shaft and driven by an electric motor which would do this work very satisfactorily. The little tool that is used in Reading shops, herewith illustrated, is arranged to work from the drill socket of any ordinary portable drill that may be too large to crowd into the space from which the hole is to be drilled. It consists of a frame casting shown at the left of our engraving. In this two beveled grooves with their shafts are run. At the outer end of one of these shafts there is a shank which goes into a No. 5 socket from which the power is to be derived. The beveled gear which meshes in with this is keyed to a steel sleeve having a slot cut in it, into which a feather is laid and through which the spindle carrying a drill socket works. The spindle is forced down against the work by means of a screw working on the same principle as that used for the feed of an ordinary ratchet.

ONE-TON TRAVELING CRANE.

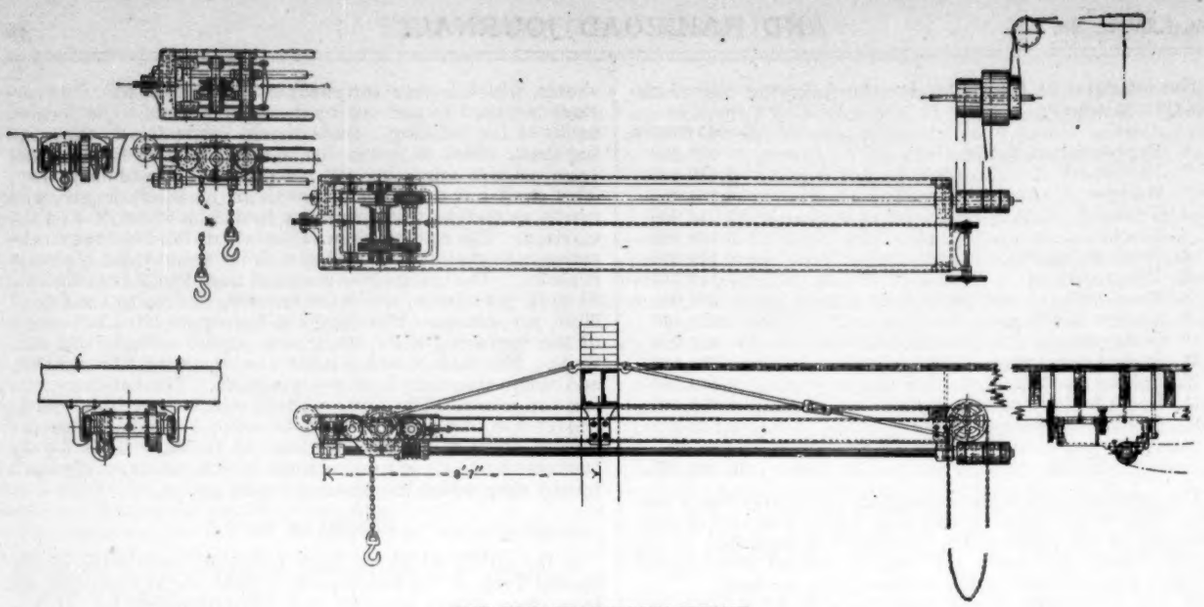
A very convenient power traveling crane is located in the frame shops just under the roof. The crane itself consists of two 8-in. channel beams, which are held to the wall of the building by brackets, as shown in the engraving. This bracket is bolted to a cast-iron beam which is built into the wall. The channels are also trussed by the truss rods, as shown, which have a turn-buckle for adjustment. The carriage is racked in and out by means of a chain-wheel located inside of the building. Immediately below this is the hoisting shaft, which is driven by belts shifting on to tight and loose pulleys admitting of reversal in the ordinary way. This shaft has a key-seat throughout its whole length, and carries an endless screw meshing in with a worm gear on the carriage. The endless screw is also carried in bearings on the carriage, so that its relationship with its worm-wheel is always constant. The belting is so arranged that the lift is at the rate of 20 ft. per minute, while the lowering is done at the rate of 30 ft. per minute. The details at the upper left-hand corner of the engraving show the general construction of the carriage. The chain-wheel is made to revolve eight revolutions, and designed to carry 1,464 lbs. per tooth. The hoisting chain is a ¼-in. chain. The driving shaft, which runs from end to end of the crane, is designed to make 170 revolutions per minute, is 2¼ in. in diameter, and 22 ft. long. It is a very convenient and rapid running hoist, which can be readily built by any shop which has occasion for its use.

PNEUMATIC HOIST.

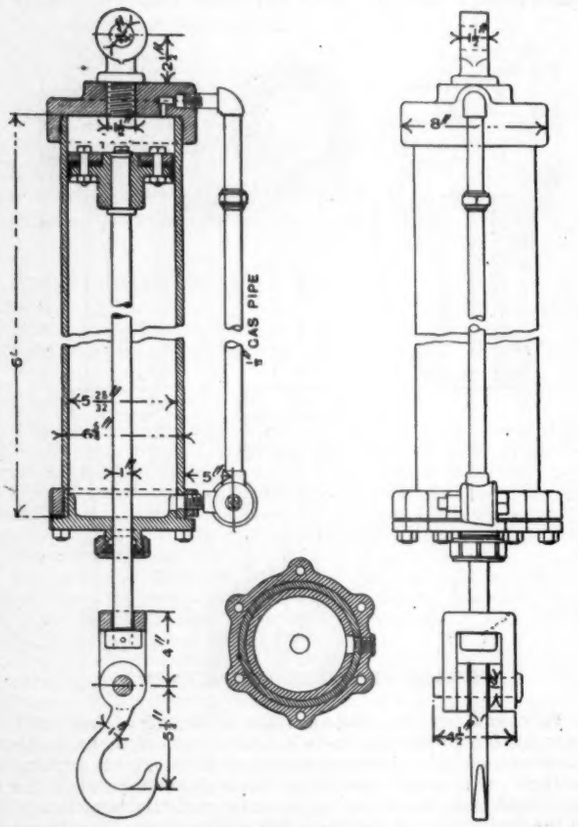
In the article which we have published descriptive of the Special Tools of the Delaware & Hudson Canal Company, we have given a very complete and comprehensive list of hydraulic pressure appliances as used for hoisting. In the Reading shops there is a small pneumatic hoist which is giving very good results. Between the advocates of hydraulic power and compressed air there is, as our readers are probably well aware, considerable earnestness of debate, each arguing that their own special system is the more economical of the two. Each one, however, seems to be perfectly practicable, and the desirability of installing one or the other in a railroad shop will depend to a great extent upon the pressure which is most convenient. Where there is an air pressure available in the shop, the hoist which we show will certainly be a very proper one to install. It consists of a cylinder bored out to 5⅝⅝ in. in diameter, with an outside diameter of 6⅝ in. It is 6 ft. long over all, and is made of a piece of 6-in. extra heavy wrought-iron pipe screwed into a head at the top, which is provided with an eye-bolt for suspending the hoist. At the lower end a ring is screwed upon the pipe, to which the lower head, with the stuffing-boxes, is bolted. The piston is the ordinary cast-iron head, with a follower holding a cup packing in position. The piston-rod is 1 in. in diameter, and is attached to the yoke of the hook by a nut held in position by a split key. The arrangement of the piping is clearly shown. The pipe making connections between the top and bottom pressures of the cylinder is ¼-in. gas pipe. Our other engraving, showing the valve used for operating the hoist, gives a very clear idea of its design. It is shown in cross and vertical sections, and the valve is attached at the lower end of the vertical pipe, as shown by the engraving. The valve is a self-packing



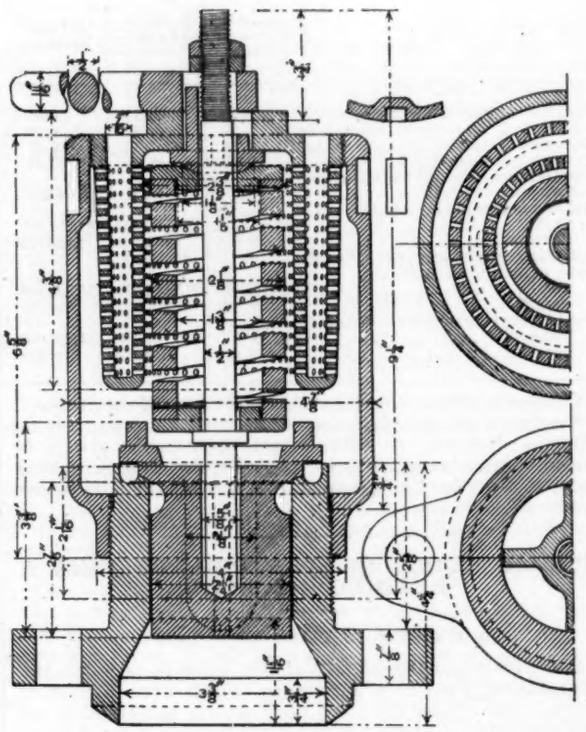
HORIZONTAL DRILLING ATTACHMENT.



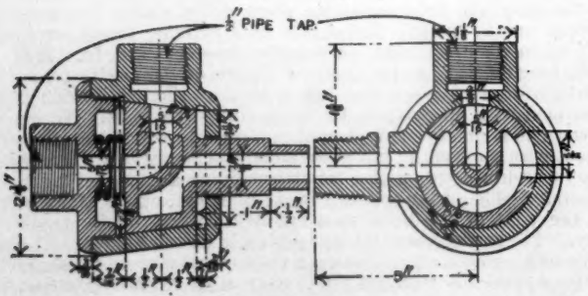
ONE TON TRAVELLING CRANE.



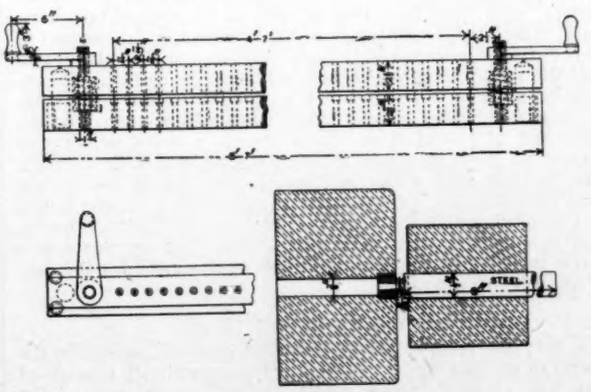
PNEUMATIC HOIST



MUFFLED POP SAFETY VALVE.



VALVE FOR PNEUMATIC HOIST.



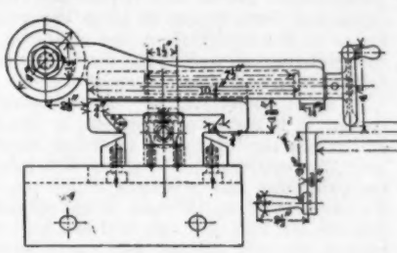
JACKET PUNCH.

SPECIAL TOOLS IN THE READING SHOPS OF THE PHILADELPHIA & READING RAILROAD.

three-way plug-valve. Air is admitted at the left-hand side of the vertical section, as shown, and comes immediately against the bottom of the valve, holding it up against its tapered side with the assistance of the small spring that is shown. The valve may be turned so as to admit air either to the bottom or the top of the cylinder, as may be desired. Of course when a load is on the hook no air need be admitted to the top of the cylinder for the purpose of lowering, but sometimes when it is up and no weight is attached the frictional resistance of the packing against the cylinder will be sufficient to hold it in that position unless some effort were exerted to force it down. The exhaust is led out through the center of the handle and blows into the atmosphere. It will be readily understood that when air has been admitted to the lower part of the cylinder it can be shut off and exhausted, and then air admitted to the upper end of the cylinder or to exhaust with perfect ease.

STANDARD MUFFLED POP-VALVE.

In our description of the Philadelphia & Reading shops, published in our issue for November, 1893, we gave a short memoranda of a small room which is set apart for the testing and the setting of the pop-valves used upon the locomotives. These valves are tested under steam pressure, and so adjusted that they will blow down about 4 lbs. The company own such a large number of locomotives that they have found it to be to their advantage to make their own valves rather than purchase them from manufacturers. The valve which they use is a combination pop and muffler, a vertical section of which we give in the accompanying engraving. It will be seen that it does not differ in essential particulars from the construction of the other pop-valves already upon the market. The main valve is of 4 in. diameter, with the wings extending well down into the body of the main casting, so that there is no danger of its being thrown out of alignment, while there is a play of $\frac{1}{64}$ in. between the wings and the casing. The seat of the valve is rounded instead of being straight, as it is frequently made. The groove outside of the valve-seat is turned to a gauge and is about $\frac{3}{8}$ in. deep from the top of the casing. The spring is made of $\frac{3}{8}$ in. square steel, $2\frac{1}{4}$ in. outside diameter, and rests upon a collar that in turn stands on a shoulder of the stem which comes down through the center of the main valve, resting upon it $1\frac{13}{16}$ in. below the valve-seat. Outside of the spring there is a U-shaped ring perforated with $\frac{5}{32}$-in. holes forming the muffler, and through which the escaping steam is allowed to pass. The valve is screwed down by means of a handle and screw shown at the top of the engraving. The valve does not differ particularly from those which are upon the market, but is simply given in order to show the practices of one great road that manufactures its own valves, and from which it is obtaining very satisfactory results.

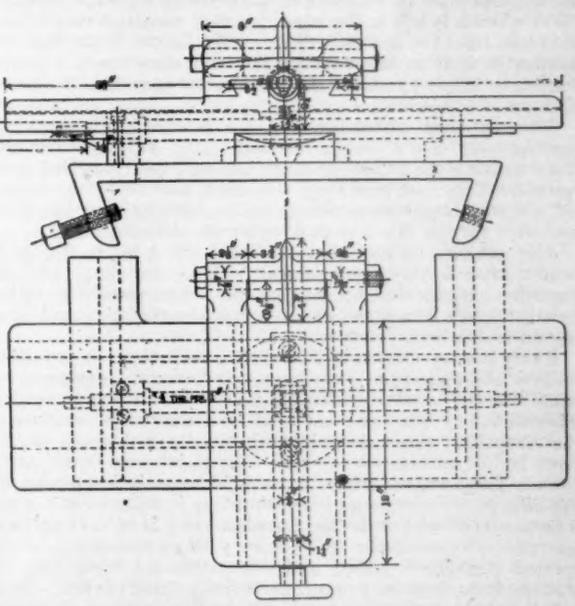


JACKET PUNCH MACHINE.

Every sheet-iron worker who has had to do with the placing of jackets on locomotive boilers knows the difficulty which he experiences and the time which it occupies in punching the necessary rivet holes. The little tool which we illustrate is one designed at the Reading shops for punching a large number of these holes at one and the same time. The large engraving at the lower right-hand corner shows the shape of the punch and dies. The punch is $\frac{5}{64}$ in. in diameter, and enters a steel die which is let into the frame below. The machine consists of two bars, with a number of these punches and dies arranged at intervals of $1\frac{1}{4}$ in. apart from center to center, and which are brought together by screwing down on the handles operating the nuts at either end of the machine. When the machine is screwed down in this way all of the holes are punched exactly in line and at the proper spacing apart. Turning back the handles slackens off the pressure on the back of the upper portion of the frame and it is thrown up, thus disengaging the punches by means of the springs, which are placed about the stem of the screw.

GRINDSTONE-TRUING DEVICE.

Every shopman where the grindstone is used for sharpening tools or for other purposes knows the disadvantages which accrue from its use, and the terrible dust which is usually raised by the ordinary apprentice truing down a grindstone after it has been worn out of shape by repeated grindings. It is a piece of work which must necessarily be done, and the dust which it creates is such as to be not only stifling to the workmen in the immediate vicinity, but decidedly injurious to all bearings and working parts of machinery with which it comes in contact. The device which we illustrate is a very simple affair, and can be readily made in any shape. It consists of a bed-piece of cast iron, which may be fastened to the frame of the grindstone by set screws, and on this bed-piece there is a transverse sliding carriage operated by a screw like an ordinary lathe. This carries a second carriage operated in the same way, the latter carrying a chilled wheel revolving on an arbor at its front side. The operation and the method of doing the work will be very readily understood. The bed-piece is clamped in position and the lower carriage run so that the chilled piece is opposite that portion of the wheel which is running the highest. The screw of the upper carriage forces this chilled wheel down against the grindstone and cuts away any projection which may exist there, and by working it backward and forward as the stone is cut away, it is a very short piece of work to remove all of the excrescences which have been raised by the tool grinding, and bring it back to a condition of roundness that is so desirable for this class of tool. The apparatus may be left clamped in position and the stone trued up every day, or as often as it may be desired to keep it in perfect condition; and where such a device as this is available and can be used at a moment's notice, it is probable that the wheel will be kept in perfect shape; but where we depend upon the iron bar and the apprentice attachment, the probabilities are that the stone will be allowed to become so badly out of true that it will be impossible to use it before any steps will be taken to bring it back into shape.



GRINDSTONE TRUING DEVICE.

THE KINGSLAND SHOPS OF THE DELAWARE, LACKAWANNA & WESTERN RAILROAD COMPANY.

We believe it is about a year ago that the Kingsland shops of the Delaware, Lackawanna & Western Railroad Company were destroyed by fire. They were immediately rebuilt, but, of course, many of the older tools and special appliances, which had been designed in the shop for particular pieces of work, were destroyed, and as there is no record left of them they have not been replaced. Therefore there is little about the shops to attract especial attention on the ground of its novelty. There are, we believe, 162 engines to be taken care of, and the floor space and pits available for the work render it necessary that every inch should be utilized to the utmost of its capacity, and even then it is difficult to get out the work as it is required. It is probable that before long the shops will be enlarged and more pits added. However, there are a few little wrinkles about the shop which are of interest and may be worth imitating by others.

The squaring machine for driving-wheels is utilized for turning off crank-pins while in position in the wheels. This is done by clamping the wheels on the centers and in position in the ordinary way, and then instead of the boring bar, which is used for boring them out, an attachment is put on with an overhanging tool that is driven by an independent belt and which turns off the crank-pins, so that the centers are accurately located the proper distance from the driving center. It is, of course, necessary to treat both wheels in this same way, but it has been found that the work is very satisfactory, and the pins can be turned off smooth enough for immediate use, and far more rapidly than it would be possible to remove them and true them up in a lathe for reinsertion. The tires are all shrunk upon and taken off from the driver centers by the use of the Wells light. In our issue for March, 1893, we published a description of the apparatus with which the Wells light is adapted for this purpose. The time which was required in the test reported at that time was 14½ minutes for each tire, but when this was done the workmen were not skilled in the handling of the apparatus, and it was evident to the spectators that a more rapid handling would be accomplished when a better drilled corps had charge of the work. This is the case, and it now only requires from 10 to 12 minutes to heat a tire and remove it.

The old method of using an injector for testing the boiler is in use here. An injector is attached to the boiler in the ordinary way, and forces the water in until the requisite pressure has been obtained.

There is a peculiar wrinkle, at least it is peculiar to us, in regard to the manufacture of piston-rods, that is giving very good satisfaction. Instead of having the rod hammered out and then turned off in the ordinary manner, the rod is hammered, and while it is still hot is given a three quarter twist from end to end. This seems to so interlace the fibers of the metal, that after it is turned off it possesses a greater strength than when it is left in the condition that usually obtains when it comes from the hammer direct. We do not know that this method is used in other shops, but it is considered in Kingsland to be a very great and desirable improvement in the manufacture of piston-rods.

The standard piston-head in use is solid with the rings sprung over and a couple of small holes drilled underneath for admitting the steam pressure beneath the rings that is required. Two cast-iron rings are used, and these are turned off slightly larger than the cylinder, sprung over the head and then sprung down so as to enter the cylinder.

The exhaust nozzles that are used are 4 in. in diameter, which gives a very even exhaust. They are single and the partition extends well up, so that there is no possibility of the exhaust passing over from one cylinder to the other and causing an undue back pressure.

Every master mechanic has experienced more or less difficulty with breaking of rod-straps that have been designed too small for the service which they are called upon to render. This difficulty has been obviated on a number of engines in the Kingsland shops, by widening out the rod-straps on the front end of the connecting-rod. There is really no necessity for any flanges here, as the box is held securely in position by the sides of the cross head when the strap is widened out, until it comes in contact with the cross-head and is held in position laterally. By widening it out a very large percentage of increased strength is added, and where this has been done all trouble from broken straps has entirely disappeared. It is nothing more than would suggest itself to any one, and yet there are some who are so firmly convinced that a flange on the brass is necessary, that they will hesitate to widen the strap. It is a parallel case with the collarless crank-pins, which came into use some time ago on the main driving-wheels. The box of the side rods and the main rods coming together hold each other firmly in position, and there is no use for a collar on the crank-pin, except to weaken the same and make work in the shop.

Some months ago there was a discussion at the New York Railroad Club regarding the broken mogul frames, and very little information was elicited as to their causes. The nearest approach to actual statement of the case being that the frames were not strong enough for the work. Some time after the meeting we saw some mogul frames in which the fillets on the inside of the pedestals were not more than three-quarters of an inch in radius, and these engines were giving a great deal of trouble by breaking through at this point, clearly proving the efficiency and necessity of a good large fillet. While these engines did not belong to the Delaware, Lackawanna & Western Road, and although all the engines there had large and substantial fillets, it has been found that it is very greatly to the advantage of the engine to have the end boxes of the mogul engines keyed up rather loosely and the main boxes tightly. This allows for a little longitudinal motion as well as a free, lateral play on rounding curves, and takes the strain off from the frames by allowing the wheels to adjust themselves to the track in a proper and natural way. The Company casts their own brasses, and uses a composition of five and one-half of copper to one of tin. The cast-steel driver-boxes have brass liners of this metal. Of course in a shop which has been so recently rebuilt there are a number of very fine machine tools which are doing admirable work. Among others there is a quick return Sellers planer of the latest design that reminds one more of the quick gig of a saw-mill carriage than anything else we have ever seen in the way of a machine tool. The forward motion on this planer is about 25 ft. per minute, but the return motion is, we believe, about 125 ft.

PROGRESS IN FLYING MACHINES.

By O. Chanute, C.E.

(*Concluded from page 583, Volume LXVII.*)

The general problem having been thus decomposed into its several elements, and each element considered as a separate problem, it will be seen that the mechanical difficulties are very great; but it will be discerned also that none of them can now be said to be insuperable, and that material progress has recently been achieved toward their solution.

The resistance and supporting power of air are approximately known, the motor and the propelling instrument are probably sufficiently worked out to make a beginning; we know in a general way the kind of apparatus to adopt, its approximate extent and required texture of sustaining surfaces, and there remain to solve the problems of the maintenance of the equilibrium, the guidance, the starting up, and the alighting, as well as the final combination of these several solutions into one homogeneous design.

In spite, therefore, of the continued failures herein recorded, it is my own judgment, as the result of this investigation into the "progress in flying machines," more particularly the progress of late years, and into the recent studies of the principles and problems which are involved, that, once the problem of equilibrium is solved, man may hope to navigate the air, and that this will probably be accomplished (perhaps at no very distant day), with some form of aeroplane provided with fixed concavo-convex surfaces, which will at first utilize the wind as a motive power, and eventually be provided with an artificial motor.

The conclusion that important progress may be achieved without an artificial motor was little expected when this investigation was begun; but the study of the various experiments which have been passed in review, the perception of the partial successes which have been accomplished with soaring devices, and the general consideration of the subject, have led to the conclusion that the first problem which it is needful to solve is that of the equilibrium, and that in working this out the wind may furnish an adequate motive power.

Preliminary experiments will, of course, be tried upon a small scale, but no experiment with a model can be deemed quite conclusive until the same principles have been extended to a full-sized apparatus capable of sustaining a man, and until this has been exposed to all the vicissitudes of actual flight. It will readily be discerned that a less achievement than this would not prove an adequate performance, and that no matter how well a model might behave in still air, there would still remain the questions as to how it would behave in a wind, and how it was to solve the problems of starting up and of alighting.

It would seem, therefore, that the first problem to solve is that of the maintenance of the equilibrium at all the angles of incidence required; in rising, in sailing, in encountering wind eddies, and in alighting.

For this purpose, it is now my opinion, based upon the performance of the soaring birds and upon the partial success of some soaring devices, that the problem of equilibrium can best be solved with an apparatus which shall utilize the wind as a motive power—*i.e.*, with some form of aeroplane of sufficient size to sustain a man, with which the operator shall endeavor to perform the various manœuvres required to meet the varying conditions of actual flight, and to preserve at all times his balance in the air. In other words, a flying machine to be successful must be at all times under intelligent control, and the skill to obtain that control may be acquired by utilizing the impulse of the wind, thus eliminating, for a time at least, the further complications incident to a motor.

But whether a soaring device be first experimented with, or whether the initial apparatus be provided with a motor, the next question pertains to the conditions under which a machine carrying a man can be experimented with most safely.

Various methods have been suggested, and a few have been tried. The most obvious is to suspend the apparatus from a cable stretched between two tall masts or between two steep hills. This has been proposed many times, but we have seen by the experience of M. *Sanderval* that it does not afford sufficient length of suspending rope to permit of unimpeded manœuvres, and that experience gained in that way would scarcely be available in free flight. A preferable plan has been proposed by M. *Duryea* (and probably by others), which consists in suspending the apparatus to be experimented with from a captive balloon, anchored by several divergent ropes so as to remain a half mile or thereabouts from the ground, as shown in fig. 83. By means of a rope passing through a pulley block attached to the balloon, and thence to a windlass on the ground, the machine to be experimented with may be drawn into the air to a sufficient height to clear the gusty air conditions found at or near the ground, and there, in comparative safety, the sky-cycler might manipulate his devices, ascertain the effect of various manœuvres, and gradually gain control, skill, and confidence preparatory to trusting himself to actual flight.

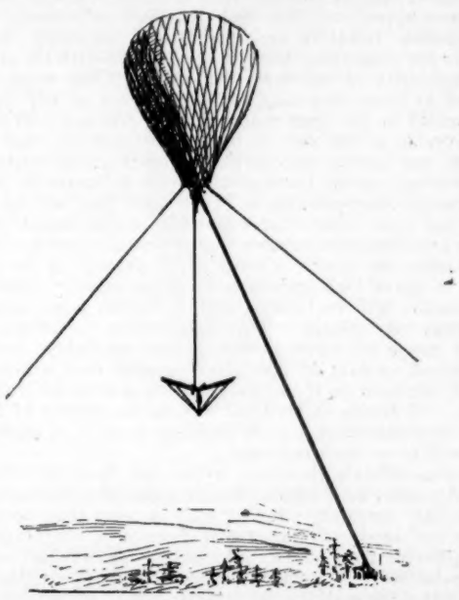


FIG. 83.—DURYEA'S PROPOSAL—1893.

This method is understood to have been employed by M. *C. E. Myers*, the aeronautical engineer, in experimenting with parachutes, and to have given promise of satisfactory results within certain limits. It is well worth testing as a preliminary trial of a flying apparatus, but it should be remembered that a machine suspended from a rope, however long, will not be under quite the same circumstances as in free flight. Even if it rises upon the wind and is wholly supported thereon it will still be hampered by the rope, and perhaps restrained from some action which it is important to understand in order to maintain the equilibrium, so that the operator will never be quite certain that he has gained complete control over his apparatus.

Other methods have been proposed by various writers. M. *Ch. Weyher*, for instance, in the *Aëronaute* for July, 1884, suggested the construction of a circular railway of 600 to 1,000 ft. diameter, upon which a large platform car, covered with a soft mattress, should carry the apparatus to be tested, attached with restraining ropes about breast high. This car to be towed at varying speeds by a locomotive, so as to afford a sustaining effect and to encounter the wind at various angles, until the operator shall master the necessary manœuvres.

M. *A. Goupil*, on the other hand, proposes a circular elevated railway consisting of a single central girder suspended by wire ropes between two rows of posts, and serving to carry a truck to which the apparatus to be experimented with may be suspended. In this case the machine might be provided with its own motive power, or towed by a wire rope, or driven by an electric motor, but in either case there would still remain the restraint of the safety suspending rope, which, as previously suggested, might vitiate the various air reactions which it is important for the operator to experience practically.

These, and other devices which may be suggested, may doubtless prove useful in making the preliminary trials with various forms of apparatus, thus testing their behavior when restrained, but there will always come a time when such apparatus, if apparently adequate, must be tried at full liberty and encounter all the contingencies of free flight. It seems clear that after the preliminary trials with models have been made, time may be saved in ascertaining the full merits of a device and in improving it, if experiments with the full-size apparatus be made at entire liberty instead of under restraint, provided adequate precautions be taken to avoid serious injury in alighting.

Referring to the various experiments which have been made with full-sized apparatus, more particularly those of *Dante*, *Le Bris*, *Mouillard*, *Lilienthal*, and *Montgomery*, it is seen that *Dante* adopted the more rational plan of all by experimenting over a sheet of water, although the exact method he pursued is not known.

Upon the whole, the best mode of procedure is probably that proposed by *Le Bris*, which want of means prevented him from adopting—that is to say, to start from the deck of a steam vessel under way, so as to obtain initial velocity, as well as to face the wind from whatever direction it may blow, and to be quickly picked up after alighting. If the machine be provided with a light buoy and line, and the operator be encased in a cork jacket or life-preserver, he may thus quickly put to the test the merits and the deficiencies of his apparatus with but little danger to himself, and ascertain whether it can be brought under control. The machine may experience breakages, the operator will doubtless suffer many duckings, he may even be stunned at times, but he is not likely to lose his life or to break a limb, as he might do were he to experiment over land.

It is believed that salt water is preferable to fresh water, over which to carry on such experiments, not only because of the greater buoyant power of the water, but especially because sea breezes are more regular and less gusty than land breezes. It is evident that it would be preferable to operate over a genial or a tepid sea, in trade-wind regions if possible, and in locations where steady sea breezes of no great intensity may be relied upon to blow almost daily. It would be desirable to select the vicinity of some projecting tongue of land or of some isthmus, where captive preliminary tests may be made, and also that there should be a cliff in the neighborhood whence models and perhaps the apparatus itself might be floated off. There are many such spots to be found within proximity of machine shops, in the Mediterranean, in the Gulf of Mexico, and on the coast of Southern California, and the attention of designers of flying machines, who may want to test the merits of their devices upon a really adequate scale, is particularly directed to the vicinity of San Diego, Cal., where all the circumstances which have been alluded to are to be found combined, even to a local railroad along the beach, on which the tests proposed by M. *Weyher* might be carried on.

All this presupposes that the preliminary experiments with small models have resulted satisfactorily, and that the designer wishes further to test the merits of his apparatus upon a practical working scale, with a machine capable of carrying a man and provided with the requisite devices to bring it under control while in the air, and thus to work out the problem of equilibrium. The expense will doubtless be considerable, and the mishaps not infrequent, but there seems to be no surer way of ascertaining whether a full-sized apparatus will preserve its balance in the air, while the risk of serious injury will be small. If such experiments finally succeed in solving the equilibrium problem, in securing safety in rising, in sailing, and in coming down, with a machine carrying its operator, an immense step forward will have been taken toward solving the other problems mentioned, and toward finally developing a safe flying machine, provided with a motor of its own and capable of being operated anywhere; for once safety has been secured under the various actual conditions of outdoor performance, it ought to be a comparatively easy and short task to work out the other questions, save perhaps those pertaining to the starting up from and alighting upon the ground.

Assuming all this to be possible—and while the mechanical difficulties are doubtless great, they do not seem to be insuperable—the final working out of the general problem is likely to take place through a process of evolution. The first apparatus to achieve a notable success will necessarily be somewhat crude and imperfect. It will probably need to be modified, reconstructed, and readventured many times before it is developed into practical shape. The invent-

or will doubtless have to construct the first models and perhaps the first full-sized machine at his own expense, in order to demonstrate the soundness of his conception and the comparative safety of its operation; but after this much is accomplished further remodelling and experiment will still probably be required to develop the apparatus into commercial value.

This phase of the evolution is likely to require the aid of capital, because the expense may be quite considerable; and inasmuch as a financial venture to develop such a difficult and novel contrivance must be gone into as a hazard, with the acceptance of the possibility of total loss as an offset for the hope of drawing a prize, the parties advancing the capital will probably require that the invention (if invention there be) shall be fully protected by patents.

In view of this probable requirement, it may be questioned whether M. *Hargrave* is quite prudent in taking out no patents for his various devices, for he hints in his last paper that he is hampered in his experiments by having to perform them in public. The difficulty arises from the fact that the experiments, to be of practical value, have to be performed out of doors, and the writer knows of some designers who, unable, on the one hand, to secure a patent—in the United States at least—until they can demonstrate the practical performance which they hope for, and apprehensive, on the other hand, of being annoyed by spectators, have retired into a wilderness to make their experiments, thus placing themselves at serious disadvantage in case a mishap of any kind occurs.

Most of the patents heretofore granted for flying machines are quite impracticable, yet the claims cover, here and there, some feature which may eventually contribute to success. It will be judicious, therefore, for designers of projected flying machines to study prior patents, and an attempt has been made in these pages to indicate some of those which contain valuable suggestions. The novelty (if any) in future patents will probably largely consist in new combinations of features already patented.

There are probably a good many arrangements of sustaining surfaces which will prove available for aeroplanes; some will prove more effective and steadier than others, and this must be ascertained by experiment; but in any event success would be hastened by a working association of experimenters in this inchoate research, for the problems, as has been seen, are many, and no inventor is likely to be in possession of all the miscellaneous knowledge and variety of talent required to perfect so novel an undertaking.

To the possible inquiry as to the probable character of a successful flying machine, the writer would answer that in his judgment two types of such machines may eventually be evolved: one, which may be termed the soaring type, and which will carry but a single operator, and another, likely to be developed somewhat later, which may be termed the journeying type, to carry several passengers, and to be provided with a motor.

The soaring type may or may not be provided with a motor of its own. If it has one this must be a very simple machine, probably capable of exerting power for a short time only, in order to meet emergencies, particularly in starting up and in alighting. For most of the time this type will have to rely upon the power of the wind, just as the soaring birds do, and whoever has observed such birds will appreciate how continuously they can remain in the air with no visible exertion. The utility of artificial machines availing of the same mechanical principles as the soaring birds will principally be confined to those regions in which the wind blows with such regularity, such force, and such frequency as to allow of almost daily use. These are the sub tropical and the trade-wind regions, and the best conditions are generally found in the vicinity of mountains or of the sea

This is the type of machine which experimenters with soaring devices heretofore mentioned have been endeavoring to work out. If unprovided with a motor, an apparatus for one man need not weigh more than 40 or 50 lbs., nor cost more than twice as much as a first-class bicycle Such machines therefore are likely to serve for sport and for reaching otherwise inaccessible places, rather than as a means of regular travel, although it is not impossible that in trade-wind latitudes extended journeys and explorations may be accomplished with them; but if we are to judge by the performance of the soaring birds, the average speeds are not likely to be more than 20 to 30 miles per hour.

The other, or journeying type of flying machines, must invariably be provided with a powerful and light motor, but they will also utilize the wind at times. They will probably be as small as the character of the intended journey will admit of, for inasmuch as the weights will increase as the cube of the dimensions, while the sustaining power only grows as the square of those dimensions, the larger the machine the greater the difficulties of light construction and of safe operation. It seems probable, therefore, that such machines will seldom be built to carry more than from three to 10 passengers, and will never compete for heavy freights, for the useful weights, those carried in addition to the weight of the machine itself, will be very small in proportion to the power required. Thus M. *Maxim* provides his colossal aeroplane (5,500 sq. ft. of surface) with 300 H.P., and he hopes that it will sustain an aggregate of 7 tons, about one-half of which consists in its own dead weight, while the same H.P., applied to existing modes of transportation, would easily impel—at lesser speed, it is true—from 350 to 700 tons of weight either by rail or by water.

Although it by no means follows that the aggregate cost of transportation through the air will be in proportion to the power required, the latter being but a portion of the expense, it does not now seem probable that flying machines will ever compete economically with existing modes of transportation. It is premature, in advance of any positive success, to speculate upon the possible commercial uses and value of such a novel mode of transit, but we can already discern that its utility will spring from its possible high speeds, and from its giving access to otherwise unreachable points.

It seems to the writer quite certain that flying machines can never carry even light and valuable freights at anything like the present rates of water or land transportation, so that those who may apprehend that such machines will, when successful, abolish frontiers and tariffs are probably mistaken. Neither are passengers likely to be carried with the cheapness and regularity of railways, for although the wind may be utilized at times and thus reduce the cost, it will introduce uncertainty in the time required for a journey. If the wind be favorable, a trip may be made very quickly; but if it be adverse, the journey may be slow or even impracticable.

The actual speeds through the air will probably be great. It seems not unreasonable to expect that they will be 40 to 60 miles per hour soon after success is accomplished with machines provided with motors, and eventually perhaps from 100 to 150 miles per hour. Almost every element of the problem seems to favor high speeds, and, as repeatedly pointed out, high speeds will be (within certain limits) more economical than moderate speeds. This will eventually afford an extended range of journey—not at first probably, because of the limited amount of specially prepared fuel which can be carried, but later on if the weight of motors is still further reduced. Of course in civilized regions the supply of fuel can easily be replenished, but in crossing seas or in explorations there will be no such resource.

It seems difficult, therefore, to forecast in advance the commercial results of a successful evolution of a flying machine. Nor is this necessary; for we may be sure that such an untrammelled mode of transit will develop a usefulness of its own, differing from and supplementing the existing modes of transportation. It certainly must advance civilization in many ways, through the resulting access to all portions of the earth, and through the rapid communications which it will afford.

It has been suggested that the first practical application of a successful flying machine would be to the art of war, and this is possibly true; but the results may be far different from those which are generally conjectured. In the opinion of the writer such machines are not likely to prove efficient in attacks upon hostile ships and fortifications. They cannot be relied upon to drop explosives with any accuracy, because the speed will be too great for effective aim when the exact distance and height from the object to be hit cannot be accurately known. Any one who may have attempted to shoot at a mark from a rapidly moving railway train will probably appreciate how uncertain the shot must be.

For reconnoitring the enemy's positions and for quickly conveying information such machines will undoubtedly be of great use, but they will be very vulnerable when attacked with similar machines, and when injured they may quickly crash down to disaster. There is little question, however, that they may add greatly to the horrors of battle by the promiscuous dropping of explosives from overhead, although their limited capacity to carry weight will not enable them to take up a large quantity, nor to employ any heavy guns with which to secure better aim.

Upon the whole, the writer is glad to believe that when man succeeds in flying through the air the ultimate effect will be to diminish greatly the frequency of wars and to substitute some more rational methods of settling international misunderstandings. This may come to pass not only because of the additional horrors which will result in battle, but because no part of the field will be safe, no matter how distant from the actual scene of conflict. The effect must be to produce great

uncertainty as to the results of manœuvres or of superior forces, by the removal of that comparative immunity from danger which is necessary to enable the commanding officers to carry out their plans, for a chance explosive dropped from a flying machine may destroy the chiefs, disorganize the plans, and bring confusion to the stronger or more skillfully led side. This uncertainty as to results must render nations and authorities still more unwilling to enter into contests than they are now, and perhaps in time make wars of extremely rare occurrence.

So may it be; let us hope that the advent of a successful flying machine, now only dimly foreseen and nevertheless thought to be possible, will bring nothing but good into the world; that it shall abridge distance, make all parts of the globe accessible, bring men into closer relation with each other, advance civilization, and hasten the promised era in which there shall be nothing but peace and good-will among all men.

THE END.

THE DRIGGS-SCHROEDER RAPID-FIRE GUNS.

THE Driggs-Schroeder rapid-fire gun, of which we give illustrations, is one of the number that is to be tested by the Ordnance Department of the United States Army, at Sandy Hook, as soon as the preparations for the trial can be completed. It has undergone the tests of the Navy Department, and has been accepted by it and placed upon several of the vessels in the Navy. Among others there are eight of these guns on the cruiser *New York*. The rapid-fire guns have been developed as a necessary result of the fleets of fast torpedo boats, which cause the naval officials of the world to recognize the fact that the best defense against their attack lay in a great volume of fire, which could best be obtained by increasing the number of small guns on board ship, and giving each one great rapidity of fire and accuracy of aim. The introduction of the metallic casing for the ammunition with the breech-operating mechanism, which reduces the time required to eject, load, and cock to the minimum, affords the best solution of the problem. In connection with this it was also necessary that the gun should be freely movable about a center pivot, and that the gunner should be protected against the effects of the recoil. These are the particular features of the rapid-fire gun as they have been developed at the present time. Although some of these guns are mounted without a recoil, it has been found expedient and feasible to use mounts which allow of a slight recoil in the line of fire in connection with automatic return to battery. When this is done the stock is attached to the rigid portion of the mount. Advantage is taken of the power of the recoil and counter-recoil to utilize it in assisting in some of the operations of the service of the gun, such as opening, ejecting, and cocking by the counter-recoil. Thus the difference in time between an aimed and an unaimed shot is reduced simply to the time occupied in pointing, and the only operations in which the rates of fire are usually compared are those of extracting and loading.

For a number of years the rapid-fire principle was only applied to guns throwing projectiles weighing 6 lbs. or less, but as their powers were increased and the quality of the ammunition improved, they have been expanded so as to embrace calibers up to 6 in.

The breech mechanism of the Driggs-Schroeder system is shown in the engraving giving the longitudinal vertical section. The top of the breech is protected and there is no opening through which rain or dirt can enter, and even when the breech is open the block and entire mechanism remain within the curtain and are completely protected. The block is very light, and thus promotes rapidity of fire. The gain in power is due to the increased travel of the shot, and is not accompanied by any sensible increase in the violence of the recoil. There are also double independent extractors. The gun can be readily placed at half-cock, and the device for automatically ejecting the empty cartridge case is readily worked.

Our illustrations of the profile and longitudinal sections of the gun show its general construction very clearly. The hoop, which is the first piece to be shrunk on the tube, is expanded by heat and slipped on from the muzzle end until the shoulder on its interior is close against a corresponding shoulder on the tube, and it is firmly held in this position until it is cold. The jacket is then put on in like manner from the breech end. This method insures perfect contact at the shoulders between the tube and hoop. On the exterior of the gun a screw-thread is cut, part of which is on the hoop and part on the jacket, and the trunnion band is screwed over it for non-recoil mountings and the saddle for recoil mountings. Thus the entire system is locked together, and all longitudinal motion between the tube and jacket or hoop is prevented. The metal used is the best quality of open-hearth steel furnished by the Midvale Steel Company and the Bethlehem Iron Company. Test pieces $2\frac{1}{2}$ in. long $\times$ $\frac{1}{2}$ in. diameter are cut from each forging, and when broken they must show the steel to possess the following characteristics: Ultimate tensile strength, 90,000 to 135,000 lbs. per square inch; elastic strength, 50,000 to 80,000 lbs. per square inch; elongation after rupture, 15 to 30 per cent. in its length in 2 in.; contraction, 20 to 50 per cent. of the original area. For the breech-blocks the specifications are made still higher, a tensile strength being required of not less than 130,000 lbs., and an elastic strength of not less than 70,000 lbs. per square inch. If the figures of any piece fall below these the forging is rejected. The forgings are all tempered and annealed, the last process being always an annealing one to relieve the internal strains of the mechanism.

In determining the gun profiles careful study has been given to the subject of slow-burning powders, the adoption of which modifies the pressure curves, and while the maximum pressure is lost, it is sustained for a much greater distance along the bore. To provide for this, the strength at the bottom of the chamber is made equal to what was necessary with quicker powders, but from the front end of the hoop to the muzzle it has been much increased.

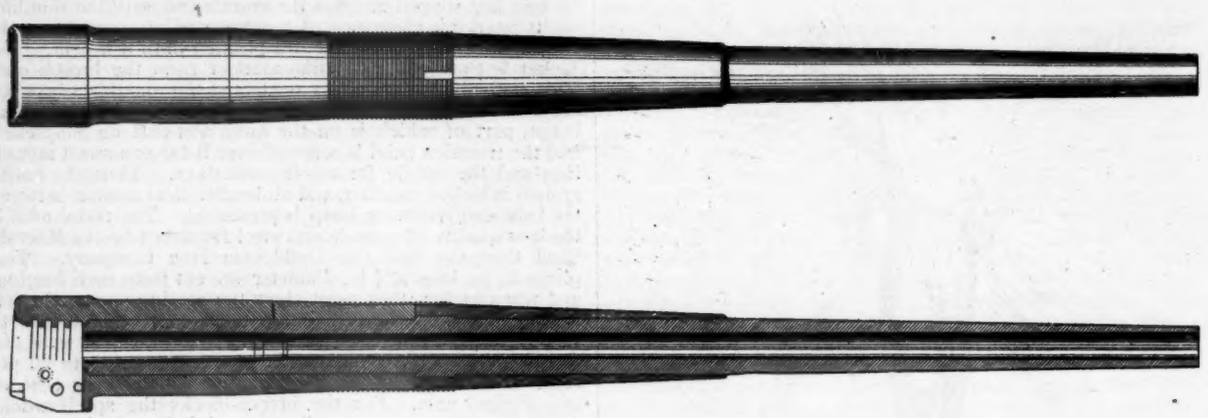
The action of the breech mechanism is very simple, as it contains no delicate parts and is not easily put out of order. The fact of the block and all of its working parts being symmetrical makes it easily understood from the drawings. Passing through the breech from one curtain to another and below the bore of the gun is the main bolt *B*, about which the block turns back. The transverse hole through the block for this main bolt *B* is lengthened in a nearly vertical direction, as shown by the dotted lines, to permit the block to descend and disengage the points from the corresponding grooves in the breech. The main cam *C*, which is shown in solid line about the hub encircling the bolt *B*, has its bearing on this bolt, and, as will be seen from the engraving, its front upper face comes to a bearing under the interior surface of the block and holds it in the upper or closed position. The back surface inclines upward to the rear, and when the cam is turned to the rear for opening, this permits the block to descend, the lower rear corner of the cam coming to a bearing on the interior bottom surface, shown by the hatched lines, and forcing it down. On the other hand, in the latter part of the closing motions the upper front surface comes in contact with the under part of the incline, just back of the point where it bears in its final position and pushes the block up into place, and then after slightly passing the center of rotation it comes under the curved surface, so that in this position the downward thrust of the block has no tendency to turn backward, and it is therefore held securely in place.

When the main cam has been turned and the block pushed down sufficiently far to clear the bands from the grooves, the semi-circular score in the upper rear corner engages the pin *L* in the block, and from that time on the movement of the two are in unison, and the block is rotated backward about the main bolt until its rear face finally rests upon the tray *T*, leaving the chamber wide open.

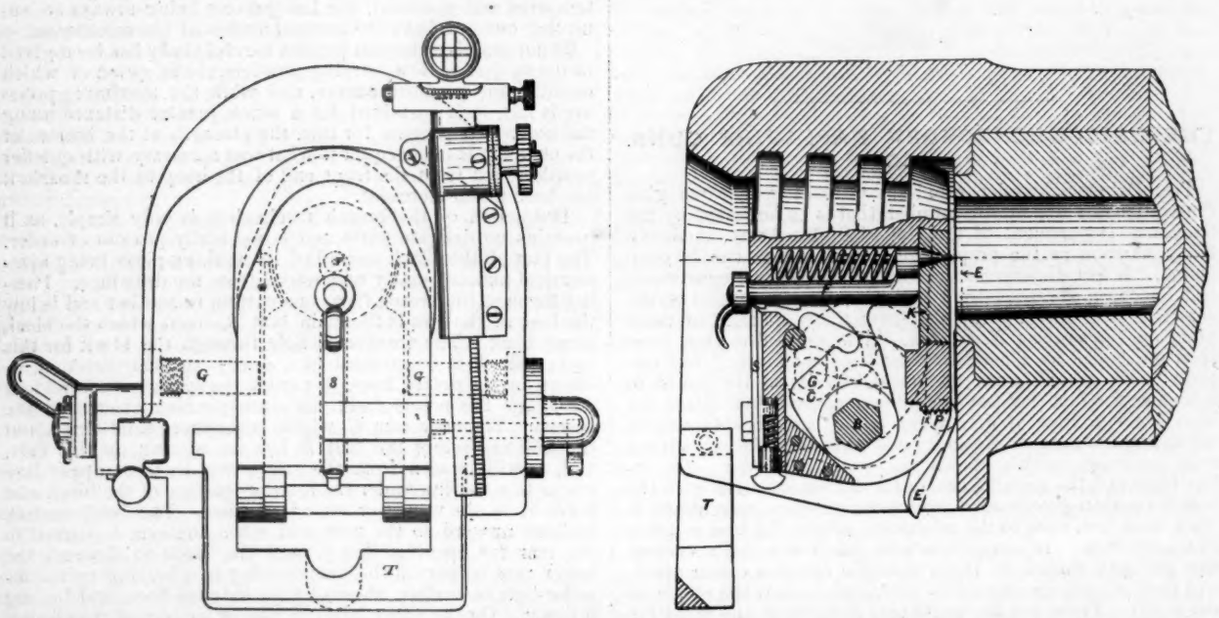
The firing-pin is marked *F*, and its spring lies to the rear of its upturned head, as shown. The full cock and half cock studs are, it will be seen, under the rear part; the sear *S*, which is actuated by a spring at the bottom of the block, presses it up against and engages the studs in succession as the firing-pin is forced to the rear. The point of a lug, projecting from the under side of a firing-pin, always rests in a circular groove hollowed out in a vertical plane in the upper surface of the main cam. When the cam is turned to the rear it first pushes back that lug and the firing-pin, so that the point of the latter is brought safely within the face of the block before it begins to descend. This motion continues, and the firing-pin is drawn back until the full-cock stud passes beyond the sear and is engaged by it. This compresses the firing-spring. When the sear is pressed down the firing-spring is released and the spring impels it forward. The finger catch, screwed on to the rear end, may also be used to retract or full cock the firing-pin without opening the breech.

motion is slow at the first, with a powerful leverage toward the latter part of the rotation of the block the motion imparted is quick.

It will be remembered that the block has a certain amount of vertical motion with regard to the main bolt, and must be kept in the lower position relatively to it during the rotation. For this purpose a guide-bolt, *G*, is screwed in through each side of the curtain, projecting into the guide-groove and on each side of the block. This groove is so shaped that the bolt permits only the vertical and rotary motions of the block in succession. It also has another function to perform in closing the breech after the rotary motion of the block changes to the vertical motion that is produced by the upper corner of the cam pressing on the interior inclined surface of the block. For the purpose of easing the change of motion from rotary to vertical, the part of the groove where the guide-bolt is at that instant is cammed, so as to make the bolt start the block upward before the corner of the main cam touches the incline.



PROFILE AND LONGITUDINAL SECTION OF THE DRIGGS-SCHROEDER RAPID-FIRE GUN.



REAR ELEVATION AND LONGITUDINAL SECTION OF BREECH BLOCK OF THE DRIGGS-SCHROEDER RAPID-FIRE GUN.

The extractors *E* are located one on each side, and lie flat against the rear face of the tube of the gun and in rests in the front face of the block. They revolve on pivots *P*, which work in rests in the curtain. The rear sides of these extractors form cam surfaces. The lower front corners of the block are similarly surfaced, and the grooves are slightly eccentric to the main bolt, so that after the block has been lowered and during its rotation its cam surfaces press against the extractor tools, pressing them forward and consequently bringing the extractor and heads to the rear and throwing the cartridge case out. These bearing surfaces are so adjusted that the

The motion of rotation thus merges gradually and easily into that of vertical translation.

The bands on the top and side of the block and the corresponding grooves in the breech are inclined about 2° 30′ to the front and upward, so that as the block is pushed up into position in closing it is also pressed forward and presses the cartridge case home, and in opening it readily detaches itself from the head of the case.

There is a spring-lock on the handle which, when the breech is closed, prevents the main bolt and block from moving under stress of any kind, except that applied directly to the

handle. The snap connected with this indicates by the sound when the block is in place and locked.

The sear, which slides vertically in the middle of the rear face of the block, has an arm extending to the side with a finger at the end, which is pressed downward by a toe on a rock-shaft connected with the pistol-grip and trigger, or by the firing-lanyard. When the trigger is used with recoil mounts it is placed under the stock; as the latter attaches to the stationary part of the mount there is no shock given to the hand of the firer by the recoil; the finger of the sear is in rear of the toe of the trigger, and leaves it during the recoil, being brought back in contact as the piece returns to battery. In the design adopted for the United States Navy, with a pistol-handle on the shoulder-bar, the trigger in the handle is connected directly with the sear by a chain-lanyard.

To facilitate assembling the front face of the block contains a heavy face plate, *K*, easily removed and secured; the cam and firing-pin and spring are removed and replaced there.

It must not be understood from this description that when the block is in position any strain whatever comes upon the main bolt. The bands extend well around on the side and sustain the whole force of the discharge without putting any strain whatever upon the bolt.

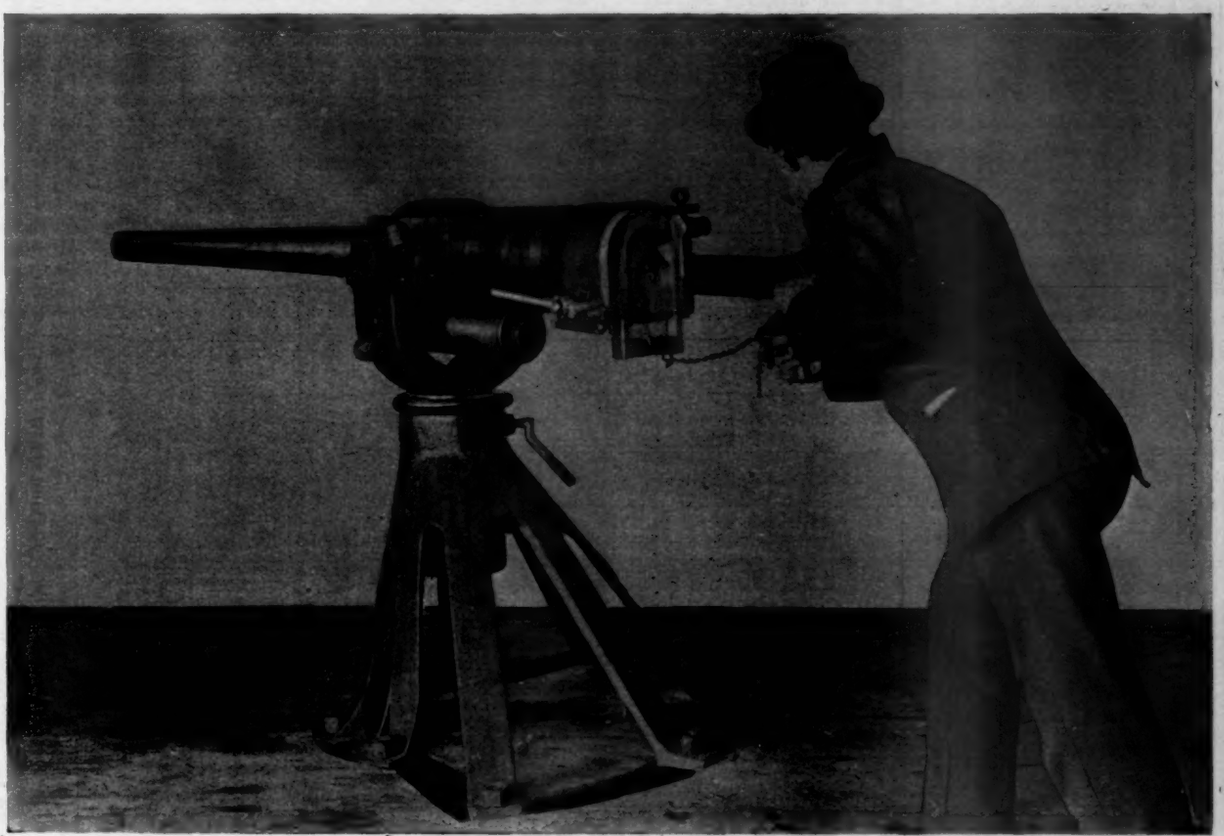
The refilling is an increasing twist on a curve connecting the initial and final angles of a semi-cubical parabola. The sights are capable of rapid changing of setting with but one hand. The rear sight has double cross wires and the front sight single wires. The advantage of this arrangement is that the gun can be pointed almost as accurately as with a telescopic sight and that there is a clear field about the trigger. The cross-bar of the sights is graduated in spacing representing 10 minutes of a horizontal arc. This has been done mainly to assist the officers commanding the guns, who are able thereby to designate the amount the eye-piece is to be moved. The space on the sight-bar represents 100 yds. in range when using the service charge.

The gun is mounted on two general types—the recoil and non-recoil. The engraving which we present shows it on the recoil mounts, which is known as Fletcher hydraulic recoil mount. For this mount the trunnion band is dispensed with, and the gun is screwed into a gun-metal casting termed the saddle, having a single recoil cylinder in its main part. The cylinder contains the means for checking the recoil and returning the gun to the firing position. The recoil is checked by regulating the flow of the liquid, which is usually glycerine and water, from one side of the piston to the other. This is accomplished by forming depressions or ports in the interior surface of the cylinder. The area of the cross section of these ports varies in such a manner that, although the piston has a changing velocity, a constant pressure is maintained on the pistonhead. The return to the firing-piston is effected by means of a recoil-spring.

The guns are manufactured as 1-pdrs. high-power light, 3-pdrs., 6-pdrs., 12-pdrs., 9-pdrs., 3⅖ in., 14 pdrs., and 33 pdrs.; 70 and 100-pdrs. have also been designed.

The gun's crew consists of three men: one has his shoulder against the stock, and does the aiming and firing; the second does the loading, and the third handles the ammunition and serves the second man.

In trials which have been made with the 6-pd. guns an initial velocity of 1,870 ft. per second has been obtained. Rapidity of the firing when the gun is used, regardless of aim, has been 35 shots per minute. In a future issue we expect to publish the details of the trial with this gun, that will be held under the supervision of the Ordnance Board at Sandy Hook.



6-POUNDER RAPID-FIRE DRIGGS-SCHROEDER GUN ON NAVAL MOUNT.

The following is the general data concerning the 6 pd. naval gun which we illustrate:

Weight of gun complete	783 lbs.
" " projectile	6 "
Muzzle velocity of projectile	1,870 f. s.
Range about	4½ miles.
Rapidity of fire	33 rounds per minute.
Thickness of steel plate perforated at 200 yds	4 in.

The design of the gun is entirely American in every particular, and in this is different from any other rapid-fire gun in the Navy.

ACCIDENTS TO LOCOMOTIVE ENGINEERS AND FIREMEN.

THE object of publishing this monthly list of accidents to locomotive engineers and firemen is to make known the terrible sacrifice of life and limb that is constantly going on among this class of people, with the hope that such publication will in time indicate some of the causes of accidents of this kind, and help to lessen the awful amount of suffering due directly and indirectly to them. If any one will aid us with informa-

LOCOMOTIVE RETURNS FOR THE MONTH OF SEPTEMBER, 1893.

Name of Road.	Number of Serviceable Locomotives on Road.	Number of Locomotives Actually in Service.	Locomotive Mileage.					Av. Train.		Coal Burned per Mile.						Cost per Locomotive Mile.							Cost per Car Mile.		Cost of Coal per Ton.
			Passenger Trains.	Freight Trains.	Service and Switching.	Total.	Average per Engine.	Passenger Cars.	Freight Cars.	Passenger Train Mile.	Freight Train Mile.	Service and Switching Mile.	Train Mile, all Service.	Passenger Car Mile.	Freight Car Mile.	Repairs.	Fuel.	Oil, Tallow and Waste.	Other Accounts.	Engineers and Firemen.	Wiping, etc.	Total.	Passenger.	Freight.	
										Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	$
Atchison, Topeka & Santa Fé	822	747	.....	.... ..	. . ....	2,006,155	2,686	....	....	....	....	....	78.41	....	...	3.56	6.63	0.16	0.10	6.70	1.38	18.53	...	...	1.61
Canadian Pacific	615	....	524,741	715,821	507,724	1,748,286	2,842	....	....	....	....	....	67.65	....	...	3.44	10.72	0.34	....	5.66	1.31	21.47	....	....	3.14
Chic., Burlington & Quincy	541	....	.....	.....	.....	1,531,228	2,830	6.26	20.45	....	....	....	81.83	....	.	4.22	5.43	0.22	0.16	6.65	0.04	16.72	....	....	1.33
Chic., Milwaukee & St. Paul	857	....	.....	.....	.....	2,568,119	2,996	....	....	....	..	....	68.00	....	....	3.15	7.08	0.27	...	6.73	...	17.23	....	....	2.40
Chic., Rock Island & Pacific	564	....	589,093	1,012,540	348,401	1,950,034	3,457	....	..	62.05	78.24	38.14	66.35	....	....	2.48	6.14	0.25	2.48	6.11	0.33	15.31	.. .	...	2.00
Chicago & Northwestern	....	....	854,744	1,369,944	647,775	2,871,463	....	....	...	....	...	....	84.42	....	....	2.83	7.91	0.33	....	6.31	0.77	18.15	...	....	1.85
Cincinnati Southern	....	....	.....	.....	.....	.....	...	....	....	...	....	....	....	....	...	...	...	....	...	...	....	....	....	....	....
Cumberland & Penn.*	25	25	5,446	33,464	87,018	38,910	1,556	....	....	....	....	....	78.70	....	...	7.02	4.41	0.39	....	...	1.80	13.62	....	....	....
Delaware, Lackawanna & W. Main L.	211	183	.....	.....	.....	623,630	3,408	....	....	.. .	...	....	85.61	....	....	3.18	6.44	0.45	.	5.91	....	....	....	....	...
Morris & Essex Division	160	....	180,698	141,883	87,018	409,599	2,559	....	....	...	....	....	64.24	....	....	3.82	10.00	0.39	....	6.52	....	20.75	....	....	3.07
Hannibal & St. Joseph	...	....	.. ..	.. ...	.....	.....	....	.. .	....	....	....	....	....	....	...	...	...	....	....	....	....	.. .	....	....	....
Kansas City, F. S. & Memphis	149	...	93,233	181,231	79,623	354,087	2,411	....	....	....	....	....	61.72	....	....	3.19	5.17	0.37	0.41	7.34	...	16.48	....	....	1.62
Kan. City, Mem. & Birm	42	35	33,059	48,265	11,806	93,130	2,739	....	....	..	....	...	63.09	....	....	2.86	3.39	0.21	0.35	7.08	....	13.89	....	....	1.02
Kan. City, St. Jo. & Council Bluffs	....	....	.....	.....	... ..	.....	....	....	...	....	....	. ..	....	....	....	....	....	....	....	....	....	....	....	....	....
Lake Shore & Mich Southern	596	....	504,144	657,885	382,032	1,544,061	2,590	....	....	65.76	88.01	37.82	67.72	....	....	2.01	5.19	0.19	....	6.84	0.17	14.40	....	...	1.52
Louisville & Nashville	....	....	.....	.... ..	.....	... .	...	.. .	...	....	....	....	..	....	....	..	....	....	....	....	....	....	....	....	....
Manhattan Elevated	....	269	681,599	.....	62,394	743,993	2,765	....	....	...	....	....	38.98	....	....	2.10	7.80	0.20	....	9.50	...	19.60	....	....	3.90
Mexican Central	148	114	.....	.....	.....	334,039	2,930	..	...	....	....	....	62.26	....	....	5.71	12.32	0.46	0.22	4.73	0.88	24.32	....	....	4.26
Mil., L. S. & Western	....	....	.....	.....	.....	.....	....	....	..	....	...	....	....	....	....	....	....	..	....	....	....	....	....	....	....
Minn., St. Paul & Sault Ste. Marie	....	....	.....	.....	.....	.....	....	..	....	...	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Missouri Pacific	338	....	.....	.....	.....	966.643	3,351	4.48	16.32	....	....	...	77.91	....	....	4.78	5.53	0.32	1.07	6.31	1.36	19.37	4.12	1.41	1.89
Mobile & Ohio	107	74	72,736	104,948	48,708	226,392	3,059	..	....	....	....	....	56.64	....	....	1.23	4.06	0.21	0.78	5.73	0.99	13.00	....	...	1.43
N. O. and Northeastern	....	....	.....	.....	.....	.....	....	....	....	....	....	....	..	....	...	....	....	....	....	....	....	....	....	....	..
N. Y., Lake Erie & Western	634	414	479,699	780,783	247,947	1,508,429	3,619	5.40	24.40	90.90	133.20	81.95	102.00	16.80	5.50	3.96	7.44	0.39	2 69	7.42	1.14	23.04	....	....	1.37
N. Y., Pennsylvania & Ohio	254	173	197,665	354,934	126,541	679,140	3,926	6.30	19.10	65.50	132.30	89.40	95.73	10.40	6.90	2.68	5.78	0.31	2.10	6.88	0.98	18.73	....	. .	1.12
Norfolk & Western, Gen. East. Div.†	....	....	.....	.....	.....	.....	...	....	....	....	....	....	...	....	....	....	....	....	....	....	....	....	....	....	....
General Western Division†	....	....	.....	.....	.....	... .	...	....	....	....	....	....	..	....	....	...	....	....	....	....	....	...	....	....	....
Ohio and Mississippi	105	...	142,467	137,804	82,452	362,723	3,454	....	....	...	....	....	71.25	...	....	2.41	2.87	0.24	1.17	5.46	1.47	13.56	....	....	0.79
Old Colony	....	...	.....	.....	.....	.. ....	....	...	....	....	....	....	....	....	...	....	....	....	....	....	....	....	....	....	....
Philadelphia & Reading	...	....	464,738	299,655	902,042	1,666,435	....	....	....	....	....	....	75.41	....	. .	5.30	5.04	0.37	.	5.82	0.42	16.95	....	....	....
Southern Pacific, Pacific System	741	694	637,442	867,314	262,738	1,767,494	2,547	5.38	14.86	....	....	....	68.87	....	....	3.50	17.21	0.23	2.30	7.35	1.07	31.66	...	...	5.01
Union Pacific	993	..	525,152	1,186,012	322,637	2,033,801	3,351	6.62	17.84	...	...	....	99.17	....	....	5.45	9.29	0.39	0.82	7.97	1.10	25.02	3.62	1.69	1.86
Wabash	425	355	472,161	609,034	216,760	1,297,955	3,660	5.29	17.30	68.42	103.35	51.11	74.29	12.91	5.97	3.40	4.66	0.31	...	6.11	0.87	15.35	2.47	1.04	1.16
Wisconsin Central	150	119	127,696	210,252	58,178	396,126	3,328	....	....	....	....	...	78.33	....	....	2.32	9.34	0.20	...	6.43	....	18.29	....	....	2.36

NOTE.—In giving average mileage, coal burned per mile and cost per mile for freight cars, all calculations are made on the basis of *loaded* cars. Empty cars which are reckoned as one loaded car are not given upon all of the official reports, from which the above table is compiled. The Union and the Southern Pacific rate two empties as one loaded; the Kansas City, St. Joseph & Council Bluffs and Hannibal & St. Joseph Railroads rate three empties as two loaded; and the Missouri Pacific and the Wabash Railroads rate five empties as three loaded, so the average may be taken as practically two empties to one loaded.

* Switching engines allowed 6 miles per hour; wood, construction and gravel trains, 10 miles per hour.

† Wages of engineers and firemen not included in cost.

tion which will help to make our list more complete or correct, or who will indicate the causes or the cures for any kind of accidents which occur, they will not only be doing us a favor, but will be aiding in accomplishing the object of publishing this report, which is to lessen the risk and danger to which the men to whom we all intrust our lives are exposed.

The only, or the chief source of information we have, from which our report is made up, is the newspapers. From these the following list of accidents, which occurred in November, has been made up. Of course we cannot report those of which we have no knowledge, and doubtless there are many such.

ACCIDENTS IN NOVEMBER.

York Station, Miss., November 1.—A passenger train on the East Tennessee, Virginia & Georgia Railroad was wrecked here while running at a high rate of speed this morning. A mule on the track was struck by the engine, which was turned over with the baggage car. Fireman Jim Avery was killed.

Brooklyn, N. Y., November 1.—A rear-end collision occurred on the Fifth Avenue Line of the Brooklyn Elevated Railroad this morning, in which the engine of the second train was somewhat damaged. It was sent back to the shops running wild, and owing to a sudden change in the signals at Myrtle and Hudson avenues, the engine was thrown from the track and turned over between the two tracks. The engineer, McKenna, in attempting to close his throttle, was severely scalded, and his right arm was badly torn in an effort to reverse the engine at the time. Fireman Walter Culley had his right leg and hip severely bruised.

Batavia, N. Y., November 1.—A collision occurred here this morning between an east-bound freight and local switch engine. Engineer Frank Walbridge of the switching engine was badly hurt.

Silver Creek, N. Y., November 2.—A passenger train on the New York, Chicago & St Louis Road ran into a rear-end second section of a freight train at this point to-night. The engineer and fireman jumped after the engine had been reversed. The engineer broke the bones in his wrist and was hurt about the chest. The fireman was bruised about the head and shoulders. The rear flagman had not gone back far enough to stop the train.

Keokuk, Ia., November 2.—A south-bound passenger engine on the St. Louis, Kansas & Northwestern Railroad was wrecked at Weaver, Ia., to-night. The engine was ditched and Engineer Trap killed.

St. Louis, Mo., November 2.—The boiler of a freight engine on the Iron Mountain Railroad exploded to-night, killing the fireman, George Schader. The engineer was instantly killed, and Ed. Koopke, the fireman, was thrown out into the muddy waters of the Mississippi, where his body was not recovered.

Philadelphia, Pa., November 3.—A car drifting down a grade on the Pennsylvania Railroad near Fifty-second Street to-day jumped the track and crashed into the engine of a west-bound market train. The engineer, James Hamlin, was found dead with two pieces of wood from the splintered car forced through his body. Reagan, the fireman, jumped, broke his ankle, and received other injuries to his legs.

Montpelier, Vt., November 3.—A passenger train on the Narrow Gauge Line branch of the Vermont Central ran into an open switch at Willard's Mill near Thompson to-day. The engine was thrown down a bank and Engineer Baldwin was seriously injured about the head. The fireman was slightly injured.

Goshen, N. Y., November 4.—A lurch of an engine hauling an express on the New York, Lake Erie & Western Railroad as it left the Bergen Tunnel to-day threw the engineer, Robert H. Compton, out of the cab. He received very painful injuries, but no bones were broken.

Batavia, N. Y., November 4.—A head-end collision occurred between a west-bound express and an east-bound freight on the Lehigh Valley Railroad near Morganville this morning. Two firemen and one engineer are reported as having been killed.

Cairo, Ill., November 5.—A fast Chicago & New Orleans express on the Illinois Central Railroad was wrecked by a misplaced switch near Allen this morning. Fireman Hammond was killed. It is supposed that the switch had been turned by would-be train robbers.

Reno, Nev., November 5.—A head-end collision occurred on the Western Division of the Central Pacific Railroad between two freight trains this morning. Charles Givens, a fireman, was killed. Charles Bird, an engineer, had his left leg broken at the ankle. Thomas Moorhead, his fireman, was hurt about the head. The two trains came together in a cut at a sharp curve while going at a full speed.

Meadville, Pa., November 5.—A collision occurred between two switch engines on the New York, Pennsylvania & Ohio Railroad at this point to-day. Engineer Brown was severely cut about the head.

Lancaster, Pa., November 6.—Taylor Welsh, an engineer on the Pennsylvania Railroad, was hurt while attempting to disconnect the air-hose between two cars. As the coupling stuck, an iron bar was used to force them apart. One of the sections of the hose flew down, striking the engineer in the face, cutting him badly about the mouth.

East Des Moines, Ia., November 7.—A freight train on the Chicago & Great Western Railroad was derailed 8 miles south of Des Moines by running into a horse to-day. William Ferrell, the engineer, was badly injured.

Moberly, Mo., November 7.—A fast train on the Wabash Road ran into an open switch in the yards here this morning. The engine turned over on its left side, catching the fireman, William Malone, beneath it. He was fatally scalded, and died soon after. Frank Robertson, the engineer, was badly but not fatally hurt.

Lawrenceburg, Ky., November 8.—A freight train on the Louisville Southern Railroad ran into a rock car in a cut at this point to-day. The fireman was seriously injured.

Concord, N. H., November 9.—Daniel Coughlin, a fireman on the Concord, Montreal Railroad, while attempting to pass between two cars of a moving freight train, was thrown upon the rails, run over, and killed.

Toledo, O., November 9.—A south-bound passenger train ran into a north-bound freight train on the Hocking Valley Railroad just north of Rising Sun this evening. The collision was due to the disobedience of orders on the part of the engineer of the freight. Engineer L. H. Jones and Engineer James E. Kirlen were killed, also Fireman Jones of the passenger train.

Fort Wayne, Ind., November 10.—A west-bound limited express of the Pennsylvania Railroad ran into an open switch in the yards at this point this morning. The engine plowed through a box car on the side track, severely injuring Engineer David Raidy and Fireman Robert Griffen.

Lebanon, Ky., November 10.—A passenger train was derailed at Altamaton, on the Knoxville Division of the Louisville & Nashville Road, this morning. The engineer and fireman were badly bruised.

Newark, N. J., November 11.—Engineer Tunis and Fireman O'Brien, of the Rockaway Valley Railroad, were severely injured by the derailing of their locomotive about 2 miles from Morristown to-day. The fireman was injured by jumping, and the engineer by being struck by one end of a broken connecting-rod.

Windsor, Vt., November 11.—Joseph Pecoy, Jr., a fireman on the Boston & Maine Railroad, slipped and fell while stepping from the tender of his engine. He broke one of his arms above the elbow.

Lancaster, Pa., November 12.—A freight train of the Pennsylvania Railroad stopped with the caboose on the bridge over the turnpike to-night. Engineer Simon Brown, not knowing the caboose was on the bridge, stepped from it, and fell to the ground, 35 ft. below. He was seriously injured.

Greensburg, Pa., November 13.—Zachariah Gordon, a fireman on a freight engine, while stepping off his engine to-day had the small bones of his left leg broken in two places. The large tendon was also torn from the bone.

Philadelphia, Pa., November 12.—A rear-end collision occurred on the Iron Bridge, by which the Bound Brook Line crosses the Philadelphia & Reading Railroad, to-day. The engineer and fireman were slightly injured.

Newark, N. J., November 18.—Two freight trains collided at the Broad Street coal dumps at this point to-night. Engineer David Green was pinned down upon the right side of his cab and killed by escaping steam. His fireman, Charles Barkalow, was thrown over the boiler out of the cab, and escaped with only a few bruises.

Tipton, Mo., November 21.—A fast mail train on the Missouri Pacific collided with a switch engine at this city this evening. Fireman Frank Thompson, of the switching engine, and Fireman Harry Wheat, of the mail train, were considerably injured—Thompson probably fatally. William Clark, engineer, was also hurt in the back.

Norristown, Pa., November 21.—John H. Frohn, a fireman on the Philadelphia & Reading Railroad, was fatally injured by being run over by a train to-day.

Spokane, Wash., November 22.—An east-bound passenger train on the Great Northern Road was wrecked near Bonner's Ferry to-day. The engineer and fireman received serious cuts and bruises.

Omaha, Neb., November 22.—A fast freight train ran into an open switch just outside of the yards at Brand Island, on the Burlington route, to-night. The engine was entirely demolished. The engineer and fireman jumped while the train

was moving at a high rate of speed, and both received injuries from which they may die.

Perth Amboy, N. J., November 23.—Engineer David Orenford, of the Lehigh Valley Railroad, was stoned by a number of men while leaving Phillipsburg to-day. He was slightly injured.

Watertown, N. Y., November 23.—An engine standing in the yards of the Rome, Watertown & Ogdensburg Railroad started out to-night with no one in the cab. It ran into another engine, jarring open the throttle, which also started, and they both collided head-on with a passenger train from Cape Vincent. The engineer and fireman of the train jumped, and were only slightly injured.

Birmingham, Ala., November 24.—A disastrous wreck occurred near Carbon Hill, on the Kansas City, Memphis & Burlington Railroad, to-day. An east-bound freight from Memphis ran into a drove of cows. The engine and all of the freight cars left the track. Fireman Nutwilder was caught between the engine and tender and scalded to death. Engineer H. Barnard was also caught in the wreck and badly scalded.

Wilkesbarre, Pa., November 24.—N. T. Travis, an old non-union engineer, on the Lehigh Valley Railroad, was assaulted while on his way home to-night in a lonely part of the road. He was struck on the arm by a large stone, which disabled him for some time.

Olean, N. Y., November 24.—A collision occurred between a push engine and a work train on the Western New York & Pennsylvania Railroad, near Keating Summit, to day. Theodore Crane, fireman, was killed.

Geneva, N. Y., November 24.—A boiler on a Lehigh Valley Railroad engine exploded at North Hector to-night. The fireman was killed outright and the engineer fatally injured.

Richmond, Ind., November 25.—Curtis W. Boggs, fireman on the Pan Handle Line, fell from a water tank west of this city this morning and was seriously injured.

Perth Amboy, N. J., November 26.—A collision occurred between a Pennsylvania freight and a Lehigh Valley coal train in this city this morning. The engineer, Mallory, of the Lehigh Valley train, was killed. The engineer of the Pennsylvania engine and the two firemen escaped with slight injuries.

Batavia, N. Y., November 27.—A crown sheet on a Lehigh Valley engine was burned out and came down near this point to-night. The fireman was scalded from head to feet by escaping steam, but his injuries are probably not fatal.

New Orleans, La., November 27.—A tie placed across the track of a Mississippi Valley Railroad, 2 miles below Lutcher, caused the wreck of a gravel train to-day. Fireman Joseph Fogarty was killed, and Engineer Matthew Casey fatally injured.

Duluth, Wis., November 27.—Engineer William Ross was injured by the explosion of a boiler of a freight train near Arthur, on the Duluth and Iron Range Road, to-day. His lower limbs were paralyzed, and it is feared that his spine is injured. The cause of the explosion was an overheated crown-sheet.

Leavenworth, Kan., November 28.—A train on the Kansas Central Road ran into a small herd of stock west of here to-night. Engineer William Paterson received contusions of the knee, thigh, and ankle. Fireman Joseph Wertz had his ankle sprained.

Owego, N. Y., November 28.—An engine was derailed near the depot on the Lehigh Valley Railroad to-day, and was run into by a freight train. The engineer and fireman of the freight jumped and received some severe cuts and bruises.

St. Joseph, Mo., November 28.—A train on the Hannibal & St. Joseph Railroad ran into a train on the Kansas City, St. Joseph & Council Bluffs Railroad at their crossing in South St. Joseph yards to-night. Engineer Kimball, of the Hannibal, St. Joseph & Council Bluffs train, was thrown against his boiler and painfully hurt.

Erie, Pa., November 28.—A collision occurred between a freight train and a fast live-stock train near here, on the Lake Shore & Michigan Southern Railway, to-night. The freight was crossing over the east-bound track from a siding. Engineer Joel Gaines and Fireman W. Kirk were buried beneath their engine and killed. Engineer John Sohlinger and Fireman William Melpan had not time to jump, and the former was internally injured, while Melpan had both arms broken and was also internally injured.

London, Ont., November 28.—Thomas Brock, a fireman on the Canada Southern, fell from his train and was instantly killed.

Niagara Falls, N. Y., November 29.—Michael Haley, fireman on the New York, Lake Erie & Western Railroad, was thrown from his engine while rounding a curve to-night and quite seriously injured.

East Akron, O., November 29.—A rod on an engine hauling a passenger train broke at this place this morning. Escaping steam and flying particles severely injured the fireman.

Elmira, N. Y., November 30.—A flue on a Lehigh Valley freight engine collapsed at Van Etten this morning. Charles Swartout, the engineer, who was acting as pilot, was fatally scalded.

Our report for November, it will be seen, includes 50 accidents, in which 12 engineers and 16 firemen were killed, and 28 engineers and 22 firemen were injured. The causes of the accidents may be classified as follows:

Attacked by strikers	2
Boiler explosions	5
Broken side-rod	1
Collisions	18
Derailments	3
Falling from engine	7
Misplaced switch	5
Obstruction placed on track	1
Run over	2
Struck cattle	4
Uncoupling hose	1
Unknown	1
Total	50

PHINEAS DAVIS' STEAMBOAT.

In the last number of The American Engineer we gave an account of the life of Phineas Davis, and of his building the first locomotive, *The York*, for the Baltimore & Ohio Railroad. Since then we have received from Mr. John C. Jordan, who prepared the account from which our former article was chiefly made up, an interesting sketch of the first steamboat used on the Susquehanna River, and which was built by Davis & Gardner, the firm of which Mr. Davis was a partner. Mr. Jordan has been very assiduous in collecting all the available information about this boat, and from his account, published in the York, Pa., *Gazette* of December 6, 1893, we have made up the following account:

The first public mention of the steamboat, *Codorus*, was in the York *Gazette* of November 8, 1825, which says:

"The steamboat constructing of sheet iron at this place will be ready to launch this week. She will be taken off the stocks the end of this or the beginning of next week, and launched into the river Susquehanna at Mr. Keesy's, opposite Marietta. The following is a description of the boat taken by a gentleman of Philadelphia.

"The boat has 60 ft. keel, 9 ft. beam, and is 3 ft. high. It is composed entirely of sheet iron, riveted with iron rivets, and the ribs, which are 1 ft. apart, are strips of sheet iron, which by their peculiar form are supposed to possess thrice the strength of the same weight of iron in the square platform. The whole weight of iron in the boat when she shall be finished will be 1,400 lbs. That of the woodwork, deck, cabin, etc., will be 2,600 lbs., being together 2 tons. The steam-engine, the boiler included, will weigh 2 tons, making the whole weight of the boat and engine but 4 tons. She will draw, when launched, but 5 in., and every additional ton which may be put on board of her will sink her 1 in. in the water.

"The engine is upon the high-pressure principle, calculated to bear 600 lbs. to the inch, and the engine will be worked with not more than 100 lbs. to the inch. It will have an 8 H.P., and the boiler is formed so that the anthracite coal will be exclusively used to produce steam. The ingenuity with which the boiler is constructed and its entire competency for burning the Susquehanna coal are entitled to particular notice, and the inventors, if they succeed in this experiment, will be entitled to the thanks of every Pennsylvanian.

"The boiler is so constructed, as that every part of the receptacle for the fire is surrounded by the water intended to be converted into steam; and thus the iron is preserved from injury by the excessive heat produced by the combustions of the coal. Its form is cylindrical, its length about 6 ft., and it will be placed upright in the boat, occupying with the whole engine not more than 10 ft. × 6 ft.

"The engine is nearly completed, Messrs. Webb, Davis & Gardner being its constructors. The boat, which is the work of Mr. Elgar, is in great forwardness. The whole cost of the boat and engine will be $3,000."

[The Mr. Elgar referred to was probably John Elgar, who afterward was connected with the Baltimore & Ohio Railroad and resided in Baltimore. The writer of this note was well acquainted with him about the year 1855. He was a man of great ingenuity and a good practical mechanic.]

On November 15, 1825, the boat was finished, and was the occasion of not a little enthusiasm on the part of the citizens of York. The *Gazette* of this date says:

"The steamboat, which was built at this place, was drawn through our streets yesterday morning, on her way to the Susquehanna. She is placed on eight wheels, and such was the interest felt on the occasion, that notwithstanding being in weight more than 6,000 lbs., the weather rainy and disagreeable, the citizens attached a long rope to her, and about 60 or 70 taking hold, drew her from the west side of the bridge to the upper end of Main Street, amid the shouts and huzzas of a multitude.

"She has been named after the beautiful stream on whose banks she was brought into existence—*Codorus*—a name, that should her destiny be prosperous, that will not in future be pronounced without associating the most pleasing recollections in the minds of the citizens of this place."

On November 22 she was launched in the Susquehanna, when she was tried, and it was said:

"It is ascertained that by giving her only half the steam power, the boat is propelled against the current and a strong wind about 5 miles an hour. In the draft of water the calculation of the builders were correct, with 40 persons on board her draft is not more than 8 in."

The local papers of the period give accounts of the boat ascending the river the following spring to Harrisburg, and as far as Wilkesbarre and Bloomsburg. The Wilkesbarre *Democrat* of April 14, 1826, says of it:

"This experiment entitles Mr. Elgar to much credit and esteem, and we heartily wish him a pleasant journey to the head-waters of the Susquehanna—the place, we believe, of destination."

The York *Gazette* of July 25, 1826, indulges in rather gloomy reflections about it, and intimates that the anticipations of the promoters of this enterprise were not only unrealized, but so disappointed were the stockholding investors that it became a question among them to what use the steamboat could possibly be put in order to bring them any revenues at all.

To show that dissatisfied stockholders existed then as now is shown by the fact that Mr. Jordan reports that on April 5, 1827, two years after her first launching, one of the stockholders writes to the *Gazette* as follows:

"Between $2,000 and $3,000 have been expended upon the construction of this boat, and from the use, or rather no use being made of it, after it was built, the question may rationally be asked for what purpose has this large sum been expended, or what was the object of building the boat? Was the money levied merely to show that steamboats could be built at this place? If this was the sole object the whistle has been well paid. But I am in hopes some better use might be made of it, than suffering it to be dismantled, and becoming a prey to the corrosions of time. Suppose some of the stockholders were to employ some of the arkmen to tow it down to the tide, where perhaps it might be applied to some useful purpose. It is better to wear than rust out, half a loaf is better than no bread. Something could perhaps be obtained for it to be used as craft in the bay. At all events, a trial to do something ought to be made, and who knows what luck the stockholders might have."

What ultimately became of the *Codorus* the author of this interesting account has been unable to learn.

NOTES AND NEWS.

Contract for Gunboats.—The contract for the construction of two new gunboats, for which the Newport News Ship & Dry Dock Company, of Newport News, Va., was the lowest bidders, has been awarded to them. The price for each vessel is $280,000. The contract for the third boat has not yet been awarded.

Trial of the Cruiser "Olympia."—At the trial of the cruiser *Olympia*, on the contractor's trial trip, she made a record faster than that made by the *New York*, which was 21 knots, having run 21¼ knots. The maximum speed with the maximum power was 21.26 knots; the average for 68 hours, with heavy sea and strong winds, slightly under 21 knots.

Preservation of Wire Rope.—An expert gives the following recipe for preserving wire ropes that are to be carried under water or under the earth's surface. It consists of a mixture of 35 parts of slacked lime, and from 50 to 60 parts of tar is found, thus far to be a very satisfactory method as compared with other processes which have been resorted to. The compound is boiled and applied hot. For dry-laying cables a thick mixture of graphite boiled in tallow and one of crude linseed-oil and vegetable tar have both proved a success.

Disappearing Gun Carriage Trial.—A test of the Buffington-Crozier disappearing gun carriage was held at Sandy Hook on the afternoon of December 14. The test was for rapid firing, and 10 projectiles were fired from an 8-in. gun with full charges of 125 lbs. of powder each. All shots were fired out to sea, and the 10 rounds were fired in 12 minutes and 3 seconds. The carriage worked perfectly, and has proven itself to be a success. In our next issue we will have an illustration descriptive of the carriage.

Sea Coast Defenses.—At the end of the current calendar year the War Department will be in possession of nine 12-in. guns, twenty 10-in. guns, and thirty-four 8-in. guns ready to be mounted on carriages. Also seventy-five 12-in. mortars. In addition to the product of the Army gun factory, which is now in operation at Watervliet, the Government has contracted with private parties for 100 guns of these calibers, the first of which should be delivered to the Department for test before June 1, 1894. The manufacture of heavy ordnance is thus keeping pace with current needs, but in order to render these guns available fortifications must be prepared, and for this purpose appropriations from Congress are required.

Novel Ticket on the Belgian State Railways.—An innovation in passenger rates has been introduced on the Belgian State railroads, in the sale, at a low rate, of subscription tickets, good for various periods, which entitle the holder to travel as often and as far as he may like in any part of the country during the stated period, on any of the lines belonging to the system. The prices of these tickets for 15 days are 50 francs for first class, 38 francs for second class, and 25 francs for third-class passengers. This is about like paying $10 for a first-class ticket good on all the lines of the New York Central for as many journeys as one chooses to take, for 15 days. Only no single journey nearly as long as from New York to Buffalo is possible in Belgium.

Railway in the Holy Land.—There is now a great railway system in the course of construction which will girdle the Holy Land from one end to the other. A French company has secured a concession for a line from Beirut to Damascus, and has already commenced work on a narrow-gauge road. An English syndicate is now building a railway from Halfa to Damascus, which will be about 140 miles long, starting from Halfa, finding its way along the northern base of the range of Carmel to the plain of Esharon, through the valley east of Nazareth. Leaving Mount Tabor it will cross the river Jordan on a trestle, and then to the point known as Majemeh, where the Little Jordan joins the greater rivers At this point the road will border on the southern shore of Galilee, and almost without a curve along the famous wheat region, biblically known as the plains of Bashan, thence to the southern gate of Damascus.

Standard Time in Italy.—On November 1 "standard time" was introduced on the Italian railroads, being that of the fifteenth degree east of Greenwich, the same as in Germany and Austria, called in Europe "Central European Time." This meridian passes some 50 miles east of Naples, having but a small fraction of the kingdom east of it, and comparatively thinly peopled. Heretofore all Italian railroads, except those in Cicily, have used the time of Rome, which is quite central. At the same time the hours of the day will be numbered from 1 to 24, beginning with midnight. Twenty-four o'clock will seem quite natural to the Italians, as until recently the hours were so counted universally, beginning, however, with sunset instead of midnight. In the greatest of Italian novels, an old priest, lamenting that better times have come too late for him to enjoy them long, says that it is truly a great thing for the young, but it is "half-past twenty-three o'clock" with him.

Measuring High Temperatures.—Professor Roberts-Austen, in England, has recently devoted much attention to the measurement of very high temperatures, and has obtained results of great interest in connection with the molecular structure of alloys. He has now turned his attention to providing a recording pyrometer for use in works, and this new instrument he exhibited together with some remarkable photographic curves obtained by its aid. The pyrometer itself is a thermo-junction of platinum and platinum alloyed with rhodium; this is attached to a galvanometer and the spot of light from its mirror is received on a revolving drum covered with sensitized paper. The curves exhibited give a 24 hours' record of the variations in the temperature of the blast supplied to furnaces smelting iron. It is thus possible to account for variations in the working of these large structures, and by insuring regularity of work to avoid the occurrence of these variations, also to effect economies of fuel, which, it is antici-

pated, will attain very large proportions and will prove to be of great industrial importance in conducting this important branch of metallurgy.

Summary of Railway Wrecks.—The *Wall Street News* makes the following summary of the more serious railroad accidents and their causes since the beginning of the year:

Date.	Place of Accident.	Killed.	Injured.
Jan. 21	"Big Four;" open switch, Alton, Ill.	32	36
Jan. 28	Chicago Great Western; derailment, Kent, Ill.	3	10
Feb. 21	West Shore; derailment, Palmyra, N. Y.	3	16
Feb. 22	Pennsylvania; collision, West Philadelphia, Pa.	4	20
Feb. 22	Schuylkill Valley; collision, near Phœnixville, Pa.	4	2
April 3	Jacksonville; collision.	4	7
April 25	Bare Rock; collision, Somerset, Pa.	11	2
May 6	"Big Four;" derailment, Lafayette, Ind.	10	14
May 6	Dayton and Michigan; collision.	5	0
May 30	Tyrone and Clearfield; collision, Tyrone, Pa.	5	11
June 20	Long Island Railroad; derailment, Parkville, L. I.	10	26
July 13	West Shore; derailment, Newburg, N. Y.	5	21
July 17	Grade crossing accident, Chicago.	5	12
July 25	Baltimore and Ohio; derailment, Akron, O.	3	25
Aug. 4	Lake Shore; derailment, Lindsay, O.	3	25
Aug. 16	Boston and Albany; broken bridge	17	28
Sept. 7	Fort Wayne; collision, Colehour, Ill.	13	17
Sept. 18	"Big Four;" collision, Manteno, Ill.	8	18
Sept. 22	Wabash; collision. Kingsbury, Ind.	14	45
Sept. 27	Grand Trunk; Bellevue, Mich	3	5
Oct. 13	Michigan Central; collision, Jackson, Mich	12	40
Oct. 16	Wabash; collision, East St Louis.	0	72
Oct. 19	Illinois Central; collision, Otto, Ill.	0	10
Oct. 20	Grand Trunk; collision, Battle Creek, Mich.	27	36
	Totals.	201	548

DETENTIONS ON RAILROADS FROM DEFECTS IN LOCOMOTIVES.

In response to a letter of inquiry with reference to this subject, which appeared in The American Engineer of last month, we are able to give the following statement of total engine mileage made on each division of the road, covered by the tabular report published on p. 548 of our November number. The following figures give besides the mileage the number of detentions for the same and the number of miles run to one detention. This, of course, varies somewhat on some divisions where there are only a few old engines, as on the B Division, where the miles run to one detention is much lower than on others. The same may be said of Divisions A and F where some of the power is old. The average, however, is one detention to 24,618 miles.

The table published in November covered only machinery failures and not boiler failures. We hope to give some reports of these in the future.

Summary of Reports of Detentions to Trains from Defective Machinery, Year ended June 30, 1893, on Mileage Basis.

Division.	Total Mileage.	Total No. of Detentions.	Miles Run to One Detention.
Division A	2,955,858	91	32,482
Division B	5,934 374	152	39.042
Division C	3,853 707	137	28,129
Division D	337,733	42	8,041
Division E	2,273,977	81	28,074
Divisions F and G	3,289,431	234	14.057
Division H	4,444,649	215	20,673
Division I	3,986,263	122	32,674
Division J	3,569,884	138	25,869
Division K	446,910	51	8,763
Grand Total	31,092,786	1,263	24,618

The article which was published on pp. 505–507 of our November number, and the table on p. 548 relating to this subject, and also the blanks used for reporting detentions on the New York Central Railroad, which were given on p. 595 of our December issue, have attracted the attention of a number of railroad managers, and our readers will, we think, be interested in the following comments made thereon by several of them. Mr. P. Leeds, Superintendent of Machinery of the Louisville & Nashville Railroad, says:

To the Editor of the American Engineer and Railroad Journal:

Your circular letter to our General Manager has been referred to me. We have never made a summary of detentions and other causes outlined in that report, but every day I get a report of every detention on the road, from any cause whatever, and the number of minutes' delay on account of it. This report I criticise carefully, and take up every case individually at once, at the same time making memorandum of all breakages that would indicate weakness of construction, separate and distinct from those that are from causes of any neglect of inspection in the case of the engines. This I call my laboratory report, as, no matter what the figures may show, any failure of any one part is looked upon by me as *prima facie* evidence that there is a weakness in that point, and attention is given at once to strengthening it in our old engines by additional bracing, and in our new ones by change in design to meet the defect.

As these reports give every minute delayed, they are of a great deal of value in saving discussion and argument with parties who insist that they can make great improvements in our lubrication, etc.

For instance, where any one comes in and claims they can reduce our delays on account of hot boxes, I hand them a few weeks of these reports, and ask them to carefully go over them and note all delays on account of hot boxes, assuring them that they will find absolutely correct data in such records. This not only gives me the time that they spend in investigating such reports to attend to other business, but to a great extent reduces the number of incredulous smiles that meet a man when he makes an offhand assertion that on such a system as this the delays on account of such trouble do not exceed so many minutes per month.

The worst feature in a system in regard to anything of this kind is that, with the exception of the equipment that belongs to a certain division, every one tries to shift the responsibility on some one else on some other division. In other words, all the detention is not attributable to neglect on the division on which they occur, and it keeps any one hustling to trace down where the responsibility rests. At the same time, I believe I shall have a form of this kind made up on each division and reported, as it will surely place before each Master Mechanic the detentions on account of equipment that is directly under his charge, and by making a general report similar to the one you have, and sending to each Master Mechanic monthly, it will give a comparative idea of the result of his own practice against that of others. P. Leeds.

Mr. W. H. Baldwin, Jr., General Manager of the Flint & Père Marquette Road, says:

This table is very interesting, and I shall at once take steps to keep a record of all detentions on account of defective machinery under the headings as prescribed in this report. I think it would be very profitable information if all roads would keep this data under the same headings, as we may thereby learn the weakest parts from the experience of all. I thank you very much for bringing this matter to my attention, and remain,

W. H. Baldwin, Jr., General Manager.

Mr. G. Clinton Gardner, General Manager of the Ohio River Railroad, writes:

In connection with the subject of causes of detentions, permit me to suggest that you associate with it statistics of broken rails, as the most prolific cause of detention is due to failure of springs and their attachments. It may be found to be caused by bad track and road bed, resulting in broken rails, and as the winter approaches you perhaps will find the failure of springs to increase.

It is evident that in most cases Maintenance of Way does not receive as much attention as it should, and is always the first department to be attacked in a reduction of expenses. G. Clinton Gardner.

An officer of the Pennsylvania lines west of Pittsburgh says:

I think the report is a very useful one, and on the lines west of Pittsburgh it has been in use for 10 or 12 years, and is of course being continued.

Another prominent railroad officer writes:

I am glad to see that you are working up an interest in this matter; nothing pays a railroad company more than this does.

In the last issue of your paper you published a form for reporting defects of equipment in use on the New York Central. I have several criticisms to make on this form:

1. If every part of a locomotive and tender was put on the form, and the same system was followed out, it would be of a most voluminous description.

2. That it would induce enginemen to report work on account of its convenience, that they would not do otherwise.

3. And the one I consider the most serious objection is the fact that the Superintendent of Machinery has no check on the form; in other words, if a master mechanic or general foreman should fail to send this report in, or to suppress it, the Superintendent of Machinery would probably be none the wiser, and hence the probability is that a great many of them are not sent to him which should be. He may have a check on it, but it is not shown in your article.

I think my method of procedure is better than this, and I enclose our Form 1,004 (see copy below), which is known as the Engineman's Form, and on which, as soon as he comes in, and there has been any detention at all to his train either of cars or engines, he makes a report of it, stating what caused it as near as he can judge. This goes to the round-house foreman or to the general foreman of the station, who verifies his statement and tries to locate the trouble; it is then sent to the Master Mechanic, who confirms the report or takes any action necessary. Many times a man has to go before a Board of Inquiry and be tried; it then goes to the Superintendent of Motive Power, who often returns it for further investigation, and finally it comes to me, and sometimes even I take up the question and go into it; but whatever is done is shown on the form in full, and the reason for doing it. In addition we have hundreds of small blue prints of each part of the machinery, with which each station is supplied, and they pin one of these small blue prints to the form, and mark in red ink on it the defect or breakage. I found when I first took hold of the road that these reports did not come to me with regularity, were often suppressed if it proved convenient to do so, and, in fact, it was utterly worthless without some check, and this I devised, as follows:

The conductors have to report any detentions to their trains to the Train Masters, and a record of these is kept, with the cause, and each Division Superintendent reports to me on a second form, No. 2,456 (see copy below), the detentions to all trains on his division each month. This gives me a check against the division master mechanic, and the division master mechanic gives me a check against the superintendent, the information coming through two different sources. In this way we get everything, and the report becomes valuable.

Our men are now thoroughly broken into it and there is no objection to its use, and we have a full record at all times of everything that takes place. Each month I compile a statement of divisions of detentions, etc., a sample copy of which I send you for the month of September. You will see it covers the four following reports:

Table 1. Reports of detentions to trains from defective machinery.
Table 2. Reports of detentions to trains from steam failures.

Table 3. Reports of detentions to trains from carelessness.

Table 4. Report showing the miles run to one detention. I do not think anything more simple or complete can be devised than this form, and it has given us the most excellent results. We are eliminating the weak points wherever it is practicable to do so, and we find now that our detentions to trains from defective machinery, with everything reported, are far less than they were in 1889, when we were getting only about half the reports, and in another two or three years I hope with proper system to reduce them 25 or 30 per cent. more.

Form 1,004.

..... RAILROAD COMPANY.

ENGINEMAN'S REPORT OF ACCIDENT,

MACHINERY OR STEAM FAILURE.

Date of Accident.....	Engine Number...Train Number...
Time of Accident, Hour.....Min.....	Engineman.....
On Time or Late....Hours....Min...	Fireman ....
Delayed by Accident.. " .... "	Conductor..... .. ..
Location.....	

CAUSE OF ACCIDENT OR STEAM FAILURE.

....

....

CARS OFF TRACK AND DAMAGED.

Initials.	Class.	Number.	Damage.

DAMAGE TO ENGINE AND TENDER.

....

....

....

Respectfully Submitted,

.....Station,

Date.....189

....

Engineman.

Enginemen must fill this neatly and carefully, with full explanation of the cause of Accident or Failure of Machinery, and deliver as promptly as possible to the Division Master Mechanic or General Foreman.

Master Mechanics or General Foremen will either confirm Enginemen's Statements or make satisfactory explanation of same, with estimated amount of damage to Engine, Tender or Cars, and forward promptly to the Sup't of Motive Power, who will investigate further if necessary, and then send to Gen'l Sup't Motive Power for file in his office.

Form 2,456.

.....RAILROAD COMPANY.

SUPERINTENDENT'S REPORT OF ACCIDENT

TO MACHINERY OR STEAM FAILURE ON LOCOMOTIVES.

For.....*Div.* *Month of*.....189

Engine Number.	Train Number.	Date of Accident.	Time Delayed by Accident.	Cause of Detention.

This Form to be made out at the end of each month in the Division Superintendent's Office and forwarded to the Superintendent of Motive Power.

....

Division Superintendent.

TABLE I.

REPORT OF DETENTIONS TO TRAINS FROM DEFECTIVE MACHINERY, SEPTEMBER, 1893.

DIVISION A, PASSENGER.

Air hose clamp breaking, 851	1	
Air pump valves breaking, 620, 856	2	
Cross-head gib breaking, 857	1	
Grate arrangement breaking, 853	1	
Spring rigging breaking, 854	1	
Valve stem packing—ball joints breaking	1	7

FREIGHT.

Throttle packing blowing out, 289	1	1

DIVISION B, PASSENGER.

Main rod strap breaking, 827	1	1

FREIGHT.

Eccentric breaking, 581	1	
Main pin breaking, 385	1	
Piston head nut breaking, 1,211	1	3

DIVISION C, PASSENGER.

Air pump failing, 820	1	
Eccentric bolt breaking, 707	1	
Furnace door breaking, 812	1	
Spring hanger breaking, 814	1	
Tender truck truss rod breaking, 816	1	5

FREIGHT.

Crosshead gib bolts breaking, 437, 443, 508	3	
Frames breaking, 388, 408, 416, 449, 495, 495, 390	7	
Grate arrangement breaking, 493	1	
Muffled pop breaking, 582	1	
Safety balance stud breaking, 373	1	
Side rod bolt breaking, 594	1	
Throttle pipe lug breaking, 182	1	
Throttle rigging breaking, 378	1	
Valve stem breaking, 420	1	17

DIVISION D, PASSENGER.

Relief valve breaking, 745	1	1

FREIGHT.

Safety valve rod breaking, 7	1	1

DIVISION E, FREIGHT.

Driving axle breaking, 560	1	
Eccentric breaking, 554	1	
Guide breaking, 549	1	
Spring hanger breaking, 571	1	4

DIVISION F, FREIGHT.

Cylinder loose and working, 404	1	
Crosshead gib breaking, 355	1	
Eccentric rod breaking, 1,206	1	
Eccentric rod bolt breaking, 1,200	1	
Crank pin bolt breaking, 556	1	
Spring hanger breaking, 453	1	
Spring rigging breaking, 546, 1,202	2	8

DIVISION G, FREIGHT.

Crosshead gib breaking, 473	1	1

DIVISION H, PASSENGER.

Air pump piston rod nut thread stripped, 846	1	
Air pump packing nut thread stripped, 1,406	1	
Eccentric rod clevis bolt breaking, 762	1	
Grate arrangement breaking, 846	1	
Spring rigging breaking, 762	1	5

FREIGHT.

Crosshead gib breaking, 1,362	1	
Eccentric breaking, 535	1	
Frame breaking, 515	1	
Side rod strap breaking, 510	1	4

DIVISION I, PASSENGER.

Air hose bursting on engine, 719, 1,404	2	
Eccentric breaking, 660, 876	2	
Piston key breaking, 703	1	
Piston rod breaking, 719	1	
Safety valve lever stem breaking, 726	1	
Tender truck, gum seat in triple valve defective, 662	1	8

FREIGHT.

Driving spring breaking, 292	1	
Piston rod breaking, 999	1	
Safety valve lever fulcrum breaking, 987	1	
Steam chest breaking, 1,119	1	
Throttle packing blowing out, 963, 962	2	6

DIVISION J, PASSENGER.

Air pipe under tank breaking, 769	1	
Cylinder head breaking, 795, 877	2	
Engine truck springs breaking, 705	1	
Main rod breaking, 877	1	
Piston rod breaking, 779	1	
Spring hanger breaking, 768	1	
Spring rigging breaking, 705, 722	2	9

FREIGHT.

Air signal pipe breaking on engine, 790	1	
Crank pin nut thread stripped, 926	1	2

DIVISION K, PASSENGER.

Lifting shaft arm breaking, 1,385	1	1

FREIGHT.

Eccentric strap bolts breaking, 109	1	1

RECAPITULATION.

Division.	Passenger.	Freight.	Total.
Division A	7	1	8
Division B	1	3	4
Division C	5	17	22
Division D	1	1	2
Division E	0	4	4
Division F	0	8	8
Division G	0	1	1
Division H	5	4	9
Division I	8	6	14
Division J	9	2	11
Division K	1	1	2
Total	37	48	85
Last month	22	43	65
Same month last year	45	60	105

TABLE II.

REPORT OF DETENTIONS TO TRAINS FROM STEAM FAILURES, SEPTEMBER, 1893.

DIVISION A, PASSENGER.	5 Mins. & under.	Over 5 Mins.
Air pump exhaust coming loose, 852	1	
Bad coal, 875, 875		2
Injector intermediate check valve breaking, 852	1	
	2	2
FREIGHT.		
Incompetent engineman, 1,359		1
Injector failing to work, 1,358		1
		2
DIVISION B, PASSENGER.		
Bad coal, 756, 1,411, 1,415, 1,416	1	3
Bad fire, 1,402		1
Flues stopping up, 885	1	
Rivet head blown off, 756		1
	2	5
FREIGHT.		
Injector check valve breaking, 365		1
Steam pipes leaking, 497		1
		2
DIVISION C, PASSENGER.		
Bad coal, 811, 811, 811, 816, 818, 821	2	4
Bad coal and no arch in engine, 811, 811, 812, 814		4
Bad coal and flues leaking, 814, 814		2
Bad coal and incompetent fireman, 816, 818, 819		3
Flues bursting, 713		1
Flues stopping up and no arch in engine, 814		1
	2	15
FREIGHT.		
Bad coal and flues leaking, 390, 432		2
Exhaust base liner breaking, 584		1
Exhaust pipe working loose, 584		1
Furnace leaking, 492		1
Flues bursting, 354		1
Flues leaking, 361, 390, 437, 474, 520		5
Injector check valve breaking, 511		1
Steam pipes leaking, 360, 594		2
		14
DIVISION D, PASSENGER.		
Bad coal, 742		1
Flues leaking, 746		1
		2
FREIGHT.		
Bad coal, 7, 7, 396		3
Bad coal and flues leaking, 408		1
Flues leaking, 429		1
Flues stopped up and steam pipes leaking, 410		1
		6
DIVISION E, PASSENGER.		
Bad coal, 1,306		1
Flues leaking, 1,306		1
		2
FREIGHT.		
Bad coal, 412, 412, 412, 559, 574		5
Blow in valves, 566		1
Flues leaking, 558		1
Flues stopped up, 541		1
Incompetent fireman, 566, 589, 589, 589, 589		5
		13
DIVISION F, FREIGHT.		
Engine foaming, 374, 448		2
Flues leaking, 572, 1206		2
Injector check valve breaking, 1,209		1
Steam pipes leaking, 1,201		1
		6
DIVISION G, FREIGHT.		
Flues bursting, 372		1
Furnace patch bolt blowing out, 521		1
		2
DIVISION H, PASSENGER.		
Bad coal, 845, 845		2
Engine foaming, 762		1
Flues leaking, 839, 846, 740		3
Steam pipes leaking, 842, 843		2
Injectors failing to work, account sawdust in tank, 846		1
, 844		1
		10
FREIGHT.		
Bad fire, 502		1
Engine foaming, 80		1
Flues leaking, 502, 1,360, 1,500		3
Injectors failing to work, 446		1
Pad bolt blowing out, 535		1
Steam pipes leaking, 490		1
, 519, 1,112		2
		10
DIVISION I, PASSENGER.		
Flues leaking, 608, 662		2
		2
FREIGHT.		
Diaphragm loose, 1,386		1
Flues bursting, 958		1
Flues leaking, 956		1
Flues and mud ring leaking, 339		1
Incompetent fireman, 1,377		1
		5
DIVISION J, PASSENGER.		
Exhaust nozzle too large, 882		1
Flues leaking, 741, 769, 769		3
Injectors failing to work, 796		1
Steam pipes leaking, 882		1
		6
FREIGHT.		
Boiler check stuck and injectors failing to work, 789		1
Flues bursting, 785, 786		2
Flues leaking, 923, 1,346, 1,361		3
Injector check valves breaking, 782, 787		2
Injector cone loose and filled with cinders, 929		1
		9
DIVISION K, PASSENGER.		
Bad coal, 267		1
Flues leaking, 771, 771, 771		3
		4

RECAPITULATION.

Division.	Passenger.		Freight.		Total.	
	5 Mins. and under.	Over 5 Mins.	5 Mins. and under.	Over 5 Mins.	5 Mins. and under.	Over 5 Mins.
Division A	2	2	0	2	2	4
Division B	2	5	0	2	2	7
Division C	2	15	0	14	2	29
Division D	0	2	0	6	0	8
Division E	0	2	0	13	0	15
Division F	0	0	0	6	0	6
Division G	0	0	0	2	0	2
Division H	0	10	0	10	0	20
Division I	0	2	0	5	0	7
Division J	0	6	0	9	0	15
Division K	0	4	0	0	0	4
Total	6	48	0	69	6	117
Last month	8	40	2	68	10	108
Same month last year.	1	30	2	100	3	130

TABLE III.

CARELESSNESS.

REPORT OF DETENTIONS TO TRAINS FROM OTHER CAUSES THAN STEAM FAILURES AND DEFECTIVE MACHINERY, SEPTEMBER, 1893.

DIVISION A, PASSENGER.

Hot crank pin, 875	1	
Hot driving box, 876	1	
Hot engine truck box, 854, 875, 875	3	5

FREIGHT.

Headlight exploded, 1,398	1	1

DIVISION B, PASSENGER.

Hot engine truck box, 633	1	
Wet sand in box, 1,409	1	2

FREIGHT.

Staybolts pulled out account low water, 1,240	1	
Soft plugs melting out, 591	1	2

DIVISION C, PASSENGER.

Hot engine truck boxes, 816, 821	2	
Hot main brass, 816	1	3

FREIGHT.

Eccentric bolts coming loose, 583	1	
Hot main brass, 506	1	
Soft plug melting out, 584	1	
Waste and sparks in injector, 360	1	4

DIVISION D, PASSENGER.

Hot engine truck box, 746	1	
Hot main brass, 745	1	
Wheel guard bolt working loose, 745	1	3

FREIGHT.

Hot driving box, 428	1	
Hot main pin, 429	1	2

DIVISION E, PASSENGER.

Hot engine truck box, 1,305	1	
Soft plug melting out, 707	1	2

FREIGHT.

Hot driving box and crank pin, 560	1	
Hot main brass, 1,232	1	
Soft plug melting out, 552	1	3

DIVISION F, FREIGHT.

Eccentric rod bolt nut working off, 1,201	1	
Eccentric set screws working loose, 1,206	1	2

DIVISION G, PASSENGER.

Eccentric bolt nut working off, 801	1	1

FREIGHT.

Eccentric bolt nuts working off, 448	1	1

DIVISION H, PASSENGER.

Driving wheels off track, account too much end play, 846, 846, 846	3	
Eccentric rod clevis bolt nut lost, 841	1	
Hot engine truck boxes, 843, 846	2	
Hot main pin, 841	1	
Hot tender truck box, 842	1	
Wheels slipping, bending side rods and bursting main wheel, 1,407	1	9

FREIGHT.

Crosshead gib breaking, account insufficient lubrication, 1,363	1	
Crosshead lined too tight in Connellsville shop, 1,362	1	
Hot main pin, 1,379	1	
Hot tender truck box, 1,378	1	
Rocker arm band coming off, 1,576	1	5

DIVISION I, PASSENGER.

Air drum studs working loose, 1,351	1	
Eccentric set screws working loose, 1,388	1	
Hot engine truck boxes, 828, 1,388, 1,404	3	
Hot main brass, 608	1	6

FREIGHT.

Hot main pins, 1,386, 1,386	2	
Soft plug leaking, 959	1	
Tire working loose, 999	1	4

DIVISION J, PASSENGER.

Hot engine truck box, 708	1	
Hot main pin, 888	1	
Soft plug melting out, 741	1	3

FREIGHT.

Engine slipping, 1,366	1	
Soft plug melting out, 787	1	2

DIVISION K, PASSENGER.

Hot engine truck boxes, 1,384, 1,391	2	
Hot main pin, 1,384	1	3

FREIGHT.

Eccentric loose, 1,553	1	1

RECAPITULATION.

Division.	Passenger.	Freight.	Total.
Division A	5	1	6
Division B	2	1	3
Division C	3	4	7
Division D	3	2	5
Division E	2	3	5
Division F	0	2	2
Division G	1	1	2
Division H	9	5	14
Division I	6	4	10
Division J	3	2	5
Division K	3	1	4
Total	37	26	63
Last month	33	23	56
Same month last year	26	36	62

TABLE IV.

STATEMENT OF DETENTIONS TO TRAINS, SEPTEMBER, 1893, COMPARED WITH SEPTEMBER, 1892, ON MILEAGE BASIS.

Division.		Mileage.	Number of Detentions. Defective Machinery.	Steam Failures.	Other Causes.	Defective Machinery. Miles Run to one Detention.	Steam Failures. Miles Run to one Detention.	Other Causes. Miles Run to one Detention.	All Causes. Miles Run to one Detention.
Div. A.	1893—Pass	109,286	7	4	5	15,612	27,322	21,857	6,830
	1892—Pass	122,944	5	3	7	24,589	40,981	17,563	8,196
	1893—Frt.	127,590	1	2	1	127,590	63,795	127,590	31,898
	1892—Frt.	133,348	3	0	0	44,449	.....	.....	44,449
Div. B.	1893—Pass	189,063	1	7	2	189,063	27,009	94,532	18,906
	1892—Pass	212,939	10	4	2	21,294	53,235	106,469	13,309
	1893—Frt.	260,847	3	2	1	86,949	130,424	260,847	43,475
	1892—Frt.	318,173	2	1	4	159,087	318,173	79,543	45,453
Div. C.	1893—Pass	65,113	5	17	3	13,023	3,830	21,704	2,605
	1892—Pass	72,902	2	1	3	36,451	72,902	24,301	12,150
	1893—Frt.	232,570	17	14	4	13,681	16,612	58,143	6,645
	1892—Frt.	250,837	7	18	7	35,834	13,935	35,834	7,839
Div. D.	1893—Pass	12,105	1	2	3	12,105	6,053	4,035	2,018
	1892—Pass	11,475	1	1	0	5,738	11,475	.....	3,825
	1893—Frt.	20,781	1	6	2	20,781	3,464	10,391	2,309
	1892—Frt.	20,591	4	11	4	5,148	1,872	5,148	1,084
Div. E.	1893—Pass	38,282	0	2	2	.....	19,141	19,141	9,571
	1892—Pass	43,089	2	10	1	21,545	4,309	43,089	3,315
	1893—Frt.	153,732	4	13	3	38,433	11,826	51,244	7,687
	1892—Frt.	147,902	5	23	6	29,580	6,733	24,650	4,482
Divs. F. and G.	1893—Pass	69,841	0	0	1	.....	.....	69,841	69,841
	1892—Pass	82,370	4	2	2	20,643	41,285	41,285	10,321
	1893—Frt.	199,118	9	8	3	22,124	24,889	66,373	9,956
	1892—Frt.	199,970	17	16	1	11,763	12,498	199,970	5,881
Total, Main Stem Div.	1893—Pass	374,404	7	28	11	53,486	13,372	34,037	8,139
	1892—Pass	422,975	20	18	8	21,149	23,499	52,872	9,195
	1893—Frt.	867,048	34	43	13	25,501	20,164	66,696	9,634
	1892—Frt.	937,473	35	68	22	26,785	13,786	42,612	7,499
Div. H.	1893—Pass	117,697	5	10	9	23,539	11,770	13,077	4,904
	1892—Pass	120,135	2	4	6	60,068	30,034	20,023	10,011
	1893—Frt.	193,929	4	10	5	48,482	19,393	38,786	10,207
	1892—Frt.	251,963	11	26	5	22,906	9,691	50,393	5,999
Div. I.	1893—Pass	112,600	8	2	6	14,075	56,300	18,767	7,038
	1892—Pass	115,478	8	4	1	14,435	28,870	115,478	8,883
	1893—Frt.	217,027	6	5	4	36,171	43,405	54,257	14,468
	1892—Frt.	222,292	1	1	2	222,292	222,292	111,146	55,573
Div. J.	1893—Pass	175,894	9	6	3	19,544	29,316	58,631	9,772
	1892—Pass	118,430	8	2	4	14,804	59,215	29,608	8,459
	1893—Frt.	133,196	2	9	2	66,598	14,800	66,598	10,246
	1892—Frt.	149,213	6	7	2	24,869	21,316	74,607	9,947

Div. K.	1893—Pass	25,306	1	4	3	25,306	6,347	8,435	3,163
	1892—Pass	14,439	2	0	0	7,220	.....	.....	7,220
	1893—Frt.	17,915	1	0	1	17,915	.....	17,915	8,958
	1892—Frt.	20,426	4	0	5	5,107	.....	4,085	2,269
Total, Divs. H to K.	1893—Pass	313,800	18	12	12	17,433	26,150	26,150	7,471
	1892—Pass	248,347	18	6	5	13,797	41,391	49,669	8,564
	1893—Frt.	368,138	9	14	7	40,904	26,296	52,591	12,271
	1892—Frt.	391,931	11	8	9	35,630	48,991	43,548	13,998
Grand Total, All Lines.	1893—Pass	918,187	37	54	37	24,735	16,948	24,735	7,149
	1892—Pass	914,401	45	31	26	20,320	29,497	35,169	8,965
	1893—Frt.	1,556,705	48	69	26	32,431	22,561	59,873	10,886
	1892—Frt.	1,714,715	60	102	36	28,579	16,811	47,631	8,660

PROCEEDINGS OF SOCIETIES.

Meetings of the Central Railway Club.—The Secretary of this Club announces that the meetings of this organization will be held in Buffalo, on the *fourth* Wednesday of January, March, April, September, and October, 1894.

Proceedings of the Engineers' Society of Western Pennsylvania.—At the regular meeting, held on September 16, there was a discussion of papers on Gas and Gas Producers, and the Effect of Suddenly Applied Loads of Iron and Steel, which were read at the June meeting. There was also a paper by Mr. E Hyde describing a water-tube safety boiler. The general design of the boiler will place it in the upright class, with a central water flue extending from the base below grates to the crown-sheet and entering the sides of this flue somewhat above the grates. In the drawings illustrated the crown sheet was located at about one-third the distance from the top of the boiler toward the base. The boiler, as shown, was arranged for the use of waste heat from a heating furnace, though should it be desired to fire direct, it would be merely necessary to remove the tile from the grate-bars and place a few bricks in the furnace flue to render it at once a direct fired boiler.

Engineers' Club of St. Louis.—At the meeting of the Club on November 15 Professor W. D. Potter read a paper on Progress of Smoke Abatement in St. Louis. The paper detailed the work which had been done by the Citizens' Executive Committee on Smoke Prevention, and gave a *résumé* of the devices which had been presented for accomplishing that purpose. Only three, however, had been tested—the Hawley down draft, the Boileau, and the zigzag grate bar. About 50 different devices for preventing smoke are in use in St. Louis, and some have received quite an extensive application. The steam jet principle is used in many, down draft in others, and the coking arches in some. There are some so-called combustion powders or compounds advocated, which are to be added to the coal before or during use. These usually consist of about 25 per cent. of niter with salt, sulphate, or carbonated soda, carbonate of ammonia, etc., which are supposed to improve the combustion, prevent smoke, and slag the ashes. They are valueless, however, as the amount of niter is too small to do any good, only 3 lbs. of powder being used, while the trouble with the ashes generally is that they are already too fusible, hence clinker on the grate bars. The work of the committee has resulted in creating a demand for a better design of boiler and greater care in their operation. More care is also being exercised in selecting fuels. The steam-jet principle is usually effective in preventing smoke, but it is generally at a slightly increased consumption of fuel. One case was cited where an economy of 18 per cent. had been obtained, with a steam jet where a bed of 15 in. was carried on a hard worked boiler, though when the thickness was increased to 20 or lessened to 8 in. there was a loss in economy and capacity; that the down-draft type was not only effective in preventing smoke, but increased the efficiency and economy of the plant, and that 40 to 45 lbs. of coal per square foot of grate surface, with a good draft, or 50 lbs. with strong draft, could be burned on down-draft grate bars. The Wabash Railroad is successfully preventing smoke on its locomotives by a combination of the steam jet and baffle arch, the latter doing away with the excessive noise of the jet. A new down-draft device has also been brought out in London, England, for domestic stoves and ranges. It is quite successful, and promises to solve the smoke question for dwellings, but where smokeless fuels like coke, anthracite, oil, and gas are available, they not only prevent smoke, but are much cleaner. Crushed coke was stated to be but little more expensive than coal. In the discussion which followed it was stated that the extra expense of adding a down-draft device to a 100 H.P. plant is about $800, while the economy obtained is about 23 per cent. in fuel. It was also claimed that no ordinary grate bars would satisfactorily prevent smoke after long periods where the care of the firemen had to be depended upon, no matter how slow the rate of combustion.

PERSONALS.

MESSRS. PASCHKE & KELLEY, Civil Engineers, announce that they have opened an office in Room 9, World Building, New York, to do general engineering work. Extensive experience in Spanish-American countries and a knowledge of their languages and customs will, they think, enable them to cover an entirely new field in their occupation. They hope to be of especial service to corporations, capitalists, and engineers who desire examinations for or superintendence of structures in foreign countries.

OBITUARY.

Edward Martin.

EDWARD MARTIN died at Red Hook, N. Y., on December 3, at the age of 83 years. He was a civil engineer by profession and had laid out many railroads in this country. He located the Hudson River Railroad from Albany as far south as Hyde Park. At one time he was Superintendent of the old Galena & Chicago Railroad, and was the first President of the Rhinebeck & Connecticut Railroad. The first engine that ever drew a train of cars in America was put in order by him. He was noted for his philanthropic deeds, and had largely contributed to church work in his native town.

Manufactures.

A GLASS OIL-CUP FOR DYNAMOS AND GENERAL ENGINE BEARINGS.

THE cup herewith illustrated is provided with an "index" device for regulating the flow of oil, and an indicator-arm turning on the lid to mark the notch giving the desired feed. When desired the feed can be instantly turned off, and on again, by replacing the index lever in the notch of the indicator-arm. When the index-arm is closed the lever can be left to stand up out of the notch, thus acting as an indicator to show from a distance that the feed is shut off.

As is often the case, where a number of cups require different feeds, especially before starting engine, when an extra amount of oil is wanted, this can easily be accomplished with the "Crown," without losing the original feed, by simply moving the indicator-arm a few notches to the right, and when the established feed is again required it is only necessary to replace same in the index slide, which marks the established feed.

These cups are all made of cast brass, handsomely finished, and are heavy and durable. The oil will not leak out between the brass and the glass parts, as is the case with all ordinary spun brass cups.

Where a strictly first-class cup is wanted—one that can be relied upon—the "Crown" is recommended. Wherever they have been put in use they are giving the very best of satisfaction. They are made in eight sizes, holding all the way from ⅛ to 18 oz. of oil.

Besides the "Crown," this Company makes even other styles for various purposes, all of which are fully described and illustrated in a catalogue, which will be mailed to any address upon request.

These goods are manufactured by the Lunkenheimer Company, of Cincinnati, O.